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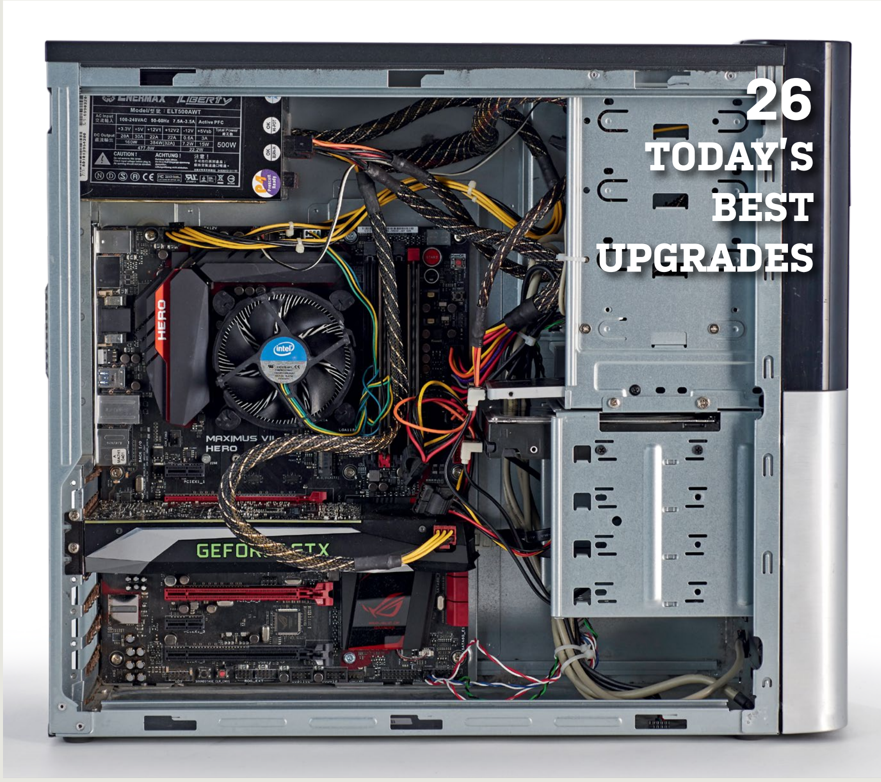

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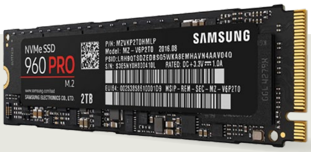

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Tuan Nguyen

IT'S TIME TO BRING IN THE NEW YEAR AND THE UPGRADES!

IT'S THE NEW YEAR, and there's no better way to celebrate than to upgrade your PC—at least, that's how tradition runs in my house. With the holiday season over, a lot of online retailers tend to put out some good deals, since sales are slower, and the market is ripe for bargains.

Of course, there's the option of buying a completely new system, but if you have a decent rig already, an upgrade or two might transform your old 2016 pedaler into a modern 2017 model. There are several ways to pump some new life into an aging system. A year in the tech world is a long time—things go by quickly!

For me, it's time to ditch my spinning disks for a solid-state system. This means getting rid of all hard drives and replacing them with much faster SSDs. You do lose some capacity, but terabyte SSDs are coming down in price. If you can store all your data on a 1TB or 2TB SSD, it's worth eating ramen for a while.

In 2016, 16GB of memory seemed like the de facto standard. But I feel 16GB is a bit cramped; 32GB is the sweet spot in my opinion. If you're still hanging on to 16GB, now's the time to get a new kit. But here's a pro tip: Just adding additional DIMMs isn't the best way to go. Instead, it's better to remove the old sticks and buy a completely new kit in the capacity that you want. This is because manufacturers bin kits, meaning individual sticks are selected for a match, and sold as a kit. Buying another kit later on, even if it's from the same model set and same manufacturer, may end up causing issues. It's rare, but it does happen.

Depending on what you're upgrading, things can go smoothly, or they can go horribly wrong. If they do go wrong, you'll want to be prepared with a Windows recovery disc. Moving to a completely different motherboard and CPU can lead to driver hell, and in some cases, prevent you from booting. This happens often when you decide to transplant your primary boot drive into a new system altogether. Granted, Windows is getting better at detecting new hardware, but it's always better to be safe than sorry!

With internal upgrades, the best way to see an immediate positive change is with an SSD. But on the outside, upgrading your display will yield an improvement you will appreciate for a long time.

I predict that 2017 will be the year of HDR (high dynamic range) displays. HDR screens display a greater range of colors, as well as brightness levels, enabling you to see more detail in an image that would otherwise appear blown or washed out. At the time of writing, HDR has only made it into high-end HDTVs, but display manufacturers are gearing up for full HDR displays. I know it's coming, as my GTX 1080 fully supports HDR. The difference in image quality is substantial, and I can't wait for a 4K HDR display.

I can still remember my 13-inch monochrome CRT display back in the day. Damn—I feel old.

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

THE NEWS

Surface Studio Launched

Microsoft reveals its next Windows 10 update, cheap VR, and the super-sexy Surface Studio

EVERY YEAR, Microsoft holds an "event" in New York, and talks up the hardware and software you'll be seeing soon. The star of this year's show was the luscious Surface Studio, a high-end desktop all-in-one, aimed at artists.

The Surface Studio is powered by a Skylake Core i5 or i7, coupled with an Nvidia GT965 or GT980. All the workings are neatly tucked into a slim base unit, making the screen wonderfully thin, at just half an inch thick. The hinged support enables the screen to go from vertical to almost horizontal (but, annoyingly, not quite—it still slopes at 20 degrees). There's just one screen size at launch—a 28-inch PixelSense, boasting a resolution of 4500x 3000 pixels (that's 192 dpi), with 10-bit color. Microsoft showed the Studio flipping between sRGB and DCI-P3 color profiles on the fly, something the target audience will appreciate.

Where the Studio really scores, though, is touch. Using the pen, you can draw on it like a proper old-school artist. It's smart enough to let you rest you arm or palm on the screen without getting confused. There's also a neat radial controller: the Surface Dial. You can drop this anywhere on to the screen, and use it to change settings without changing the primary focus, picking a brush type, for example. The Surface Studio is due to arrive early 2017, and prices range from $2,999 to $4,199. It does look pretty good, and gives Apple's iMac something to ponder on.

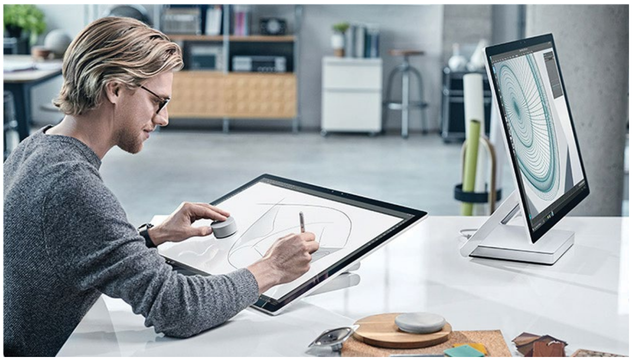
A new Surface Book has also arrived—the core components have been given a boost in raw power, and now sport a Skylake Core i7 and Nvidia GTX 965M. Prices start at a not inconsiderable $2,399.

The event also gave us more details for the next Windows 10 update, which is due spring 2017. It has been dubbed the Creators Update, and is all about mixed media—there was a lot of talk about the integration of 3D. Capture 3D enables you to use a camera to scan an object and build a 3D model, which you can drop into Paint 3D to edit, share on a new community site, or even drop into Office, if you really must.

PC and Xbox One gaming are brought closer together with game streaming built in, and an expansion of Xbox Live's Arena. For those unable to keep anything to themselves, we get My People, which puts your top contacts in a sidebar, ready to have things dropped directly on to them. There is a host of other small changes as well, some most welcome, such as the ability to select your own accent color.

Finally, we come to VR, support for which is included in the Windows update. The exact hardware details are a little sparse, but we have been promised headsets from HP, Lenovo, Asus, Acer, and Dell next spring, with prices starting from as little as $300. Microsoft claims that these are the only headsets with six degrees of freedom in the headset, so they don't require external help to track your head position, which helps to keep the cost down. There was also a demonstration of the augmented reality headset HoloLens, which is still not ready for general consumption, yet still looking promising.

All in all, it was a good day to be a Microsoft PR representative. The company is starting to look cool again. **–CL**


Microsoft's idea of a hipster using its new Surface Studio. Microsoft and hipster don't usually go together.

> The Surface Studio looks good, and gives Apple's iMac something to ponder on

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MASSIVE DDoS ATTACK

The Internet of Things has a problem

ON SEPTEMBER 21, there was a huge Distributed Denial of Service attack aimed at the DNS servers of Dyn. The servers received 40–50 times the usual levels of requests, causing significant outages and slowdowns in three waves during the day. The culprit was a piece of open-source malware called Mirai, and responsibility was claimed by the groups Anonymous and New World Hackers, although this is difficult to verify. It was the largest DDoS attack so far.

Mirai targets Linux systems, primarily those embedded into small devices, such as routers, and turns them into bots, sending out streams of spurious IP requests. What makes this attack worrying was the sheer number of devices involved: estimated at over 100,000.

The advent of the Internet of Things means there are a lot of small devices connected to the big bad Internet world, which have little thought to security. Mirai was able to be so successful because of the number of devices running on factory-default usernames and passwords. As the Internet becomes integral to modern life, we may have to be a little more careful about what we connect and how—a huge number of devices using the factory-default password is just asking for trouble.

One defense is to fight fire with fire, by using a so-called nematode, an anti-worm. It's only been speculated so far, but the idea is to use a stack overflow buffer vulnerability within Mirai to neutralize it. It can't clean an infected device, but it can stop it from spewing out its debilitating IP requests. It's a drastic solution, however, as it still involves hacking devices without permission, so is not exactly legal, either. **–CL**

KERNEL BUG EMERGES

DON'T PANIC, BUT DIRTY COW CAN EDIT YOUR ROOT FILES

DIRTY COPY-ON-WRITE (aka Dirty Cow) is a vulnerability in Linux that has been lurking under the surface since 2007, but has only recently been exploited. And it is a massive vulnerability—it even gets its own logo. The vulnerability is in a part of the Linux kernel, so is present in virtually every Linux distribution, thus it affects a lot of Android phones as well. A malicious application can tamper with a read-only root-owned executable mapped into memory. The trick is to slip between the read and write parts of a copy, and redirect the operation. If that happens, it is potentially game over.

Apparently, Linus Torvalds tried to fix the problem 11 years ago, and failed, but thought it too difficult to exploit, so quietly walked away. Since then, changes in the kernel design have made it easier to exploit. Patches are out now, and everyone affected needs to apply the updates and reboot—and that includes Android phones. Of more concern is its exploitation in embedded Linux devices, many of which rarely get patched. **–CL**

TWITTER FOR SALE?

Growth slows, and staff shrinks—interested?

TWITTER HAS 317 MILLION ACTIVE USERS, BUT the curve is flattening out, and it's looking increasingly troubled. Revenue is falling, and it's to lose 350 jobs, 9 percent of the workforce. It's also shutting its Vine video-sharing service. The company aims to be profitable by next year, but still has a $100-plus million gap to bridge.

After months of rumors, it looks as if Twitter is for sale. Google is a potential bidder, especially given the failure of Google+ to fly. Disney has been tipped, leading to a share rally, but it looks an odd fit. Salesforce is also said to be sniffing around, as is Microsoft. Facebook is one big player that isn't involved.

Twitter has had a tough year, losing 14 key executives, and failing to attract enough new users. Maintaining momentum on social media is tough; massive success is almost inevitably followed by stagnation. The fate of MySpace shows what a fickle lot we can be. Expect new management shortly. **–CL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

MICRO BIT COMES TO US
Designed to get people programing, the Micro Bit is a tiny multi-function PCB, with an ARM Cortex chip. It's huge fun, and costs only $20.

NINTENDO SWITCH
Nintendo's next offering is part handheld, part console, with detachable wireless controllers, a touchscreen, and Nvidia Pascal tech.

ATTRACTIVE SOLAR PANELS
Tesla has developed glass solar panels that look like roof tiles, so you don't have to disfigure your home.

TRAGEDIES

AIRPOD DELAYED
With no headphone jack on the iPhone 7, you'll have to wait indefinitely for the AirPod replacements as they aren't ready.

FACEBOOK RACE ISSUES
Advertisers on Facebook are allegedly illegally filtering for ethnicity; the company plans to move "Ethnic Affinity" elsewhere.

NO MORE MAGNETIC POWER
Apple's new MacBook Pro has lost the magnetic power cord, and replaced it with USB-C. Shame.

Jarred Walton

TECH TALK

What to Expect From Intel's Kaby Lake

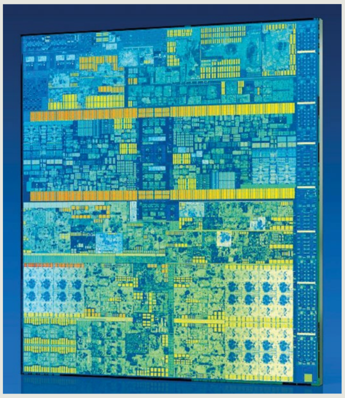
FOR THE PAST DECADE, Intel has been creating new CPUs based on its "tick-tock" model, where each tick represents a whole new process technology (starting with 65nm, back in 2006), and each tock involves a new architecture built on an existing process.

With Kaby Lake, Intel is moving away from tick-tock, and embracing a new philosophy: process-architecture-optimization. The first two correspond to tick-tock, but that third "optimization" stage is new, and Kaby Lake will be our first look at how it plays out. "Optimization" means Intel is tweaking the architecture and refining the process technology.

On the architecture front, the major update is an enhanced video decoder block that will handle 4K HEVC encoding/decoding. The block is a fixed function implementation that supports the Main10 profile, which is increasingly important for things such as 4K VP9 YouTube videos. Using a fixed function design sacrifices flexibility for improved speed and efficiency, and Intel claims Kaby Lake laptops will be able to provide up to 9.5 hours of 4K video playback. Intel also states that encoding a one-hour video into 4K HEVC can be done in 12 minutes. Kaby Lake will also feature improvements to the Speed Shift tech, introduced with Skylake, allowing the CPU to more quickly enter and exit higher clock speed states. It's the old "hurry up and go slow" mentality, letting the CPU complete a task as quickly as possible, so it can then return to a low-power idle state.

Outside these architectural changes, Kaby Lake appears to be largely the same as Skylake, with one qualification: Intel is tweaking the 14nm process, with a refined fin profile (the FinFET part of the process) it's calling 14nm+. Intel says 14nm+ will be less transistor-dense than 14nm, with a larger fin pitch and reduced channel strain. So, at roughly the same power requirements, Intel should be able to tack on a few extra hundred MHz in clock speed. For standard workloads, Intel claims Kaby Lake ultraportable and two-in-one laptops will be up to 19 percent faster than Skylake equivalents.

> Intel is tweaking the architecture and refining the process technology



Kaby Lake's new 14nm+ process technology improves clock speeds.

If you're reading between the lines, many of the above changes obviously mean a lot for laptops. Like the past several CPU releases, Kaby Lake isn't designed as a desktop-first architecture. It should already be available in laptops by the time you read this, but desktops are slated to launch in early 2017, probably coinciding with the annual Consumer Electronics Show. And, recently, we were able to find out some of the names and core specs for the upcoming desktop parts.

The Core i7-7700K will sit at the top of the stack, with a base clock of 4.2GHz—200MHz higher than the 6700K—and the maximum turbo will probably be 4.4–4.6GHz. Hopefully, it will be able to hit 5GHz with overclocking, but we'll need actual hardware to test. The Core i5-7600K will be the usual quad-core minus Hyper-Threading, with a base clock of 3.8GHz. That's the highest base clock for a Core i5 Intel has ever released, and I expect it will be the first time Core i5 has officially broken the 4.0GHz barrier—not that we haven't been doing that and much more with overclocking for years. Also apparently breaking the 4.0GHz barrier will be the Core i3-7300, clocked at an even 4.0GHz.

Along with the desktop CPUs come new chipsets: the Z270, H270, B250, Q270, and Q250. It's too early to say what exactly these new chipsets will introduce, although we do know they'll use the same LGA1151 sockets. These new boards should work with Skylake, and current Z170 motherboards should work with Kaby Lake after a BIOS update too.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

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Alex Campbell

OPEN SOURCE

Mark Your Calendars for 2017's Open-Source Events

THERE'S ONE THING that nearly all experienced Linux (and Unix) users have done: stare into the inky black abyss that is a TTY console in the wee hours of the night. (As I write this, I'm in the middle of re-installing Arch because of various reasons.) For most of the computing populace, this is a scary place, from which Balrogs are summoned.

However, if you find this place less scary, or as simply a challenging puzzle—because, let's face it, you're probably in that TTY screen because you broke something—you'll be in good company at a Linux or open-source convention or event.

Events and conventions are great places to learn about what's happening in the field. I was lucky enough to be able to attend RSA in San Francisco in 2016. While there's a lot of interesting gear to see, and lots of booths advertising things, you can learn a lot by attending keynotes or sessions. And there's a good chance you'll find yourself in the same room as someone who makes decisions about a piece of software that will affect users.

I've compiled a list of a few of the bigger events that are happening this year around the country. It's by no means complete, but I thought it would offer up a small sample of what's out there.

Southern California Linux Expo 15x
http://socallinuxexpo.org
March 2-5
Pasadena, CA
The Southern California Linux Expo (ScaLE) is based in LA, and has sessions and events to cater to all your geeky needs. From a PGP key signing party to a ham radio examination, ScaLE has plenty to offer Angelinos and those who can make it to southern California. The price of registration for a full pass was $75 in 2016.

> Events and conventions are great places to learn about what's happening in the open-source field.

LibrePlanet
http://libreplanet.org/2017
March 25-26
Greater Boston Area, MA
LibrePlanet is about "free," as in "freedom" in "free software." Hosted by the Free Software Foundation, this is the place to go if you want to increase your chances of bumping into Stallman himself. If you're a student or a member of the FSF, you get in gratis. Regular Joes will have to pony up $90.

LinuxFest Northwest
http://linuxfestnorthwest.org/2017
May 6-7
Bellingham, WA
One of the biggest Linux events in the country, and attendance is free. (You'll still need to pay for food and lodging.) The conference is friendly to Linux newbies and hackers alike.

SouthEast LinuxFest
http://southeastlinuxfest.org
June 9-11
Charlotte, NC
This is the South's answer to ScaLE and LinuxFest Northwest. You can attend for free, but you can also choose to be a "supporting" attendee for $65.

Def Con 25
http://defcon.org
July 27-30
Las Vegas, NV
While it's not strictly for FOSS, Def Con is known as the hacker event to go to. If LinuxFest is a nice camping trip, Def Con is Wasteland Weekend. Like industrial music and all-nighters? This is the place for you. Just make sure all your devices have their wireless capabilities disabled. Cost is $240, plus a room in Vegas for three days, and a hefty caffeine budget.

There are plenty more events that are to be determined this year, so if none of these fit your travel plans, don't worry. While the big events get a lot of attention, there are plenty of smaller hackathons and events to attend nationwide. And if there are none near you, you could be the prestigious founder of your own local annual FOSS event.

Alex Campbell is a Linux geek who enjoys learning about computer security.

THE LIST

MAXIMUM PC's FAVORITE HEADPHONES OF 2016

7

STEELSERIES SIBERIA 840

An upgrade of the original H Wireless, the 840s add Bluetooth to the impressive cable-free cans, for $330.

6

HYPERX REVOLVER

Mid-range perfection. An incredible headset to this day, the Revolvers personify everything that's right with the world of audio, at just $99.

5

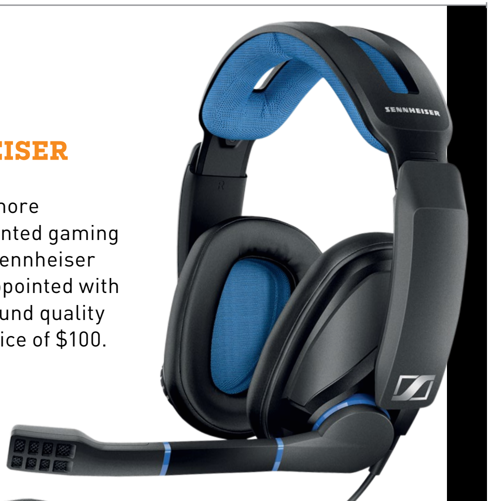
AUDIOTECHNICA ATH-M50X

The king of entry-level audiophile headphones, the ATH-M50X look stylish, provide deep, rich tones, and cost only $140.

4

HYPERX CLOUD STINGER

HyperX's reputation for good value audio is legendary, and the Stinger certainly doesn't disappoint—especially at $50.



3

SENNHEISER GSP-300

One of the more budget-oriented gaming headsets, Sennheiser hasn't disappointed with fantastic sound quality at a solid price of $100.

2

OPPO PM-3

Portable, classy, planar-magnetic beauties—the Oppo PM-3's rich soundscape is pure perfection for $400.

1

BEYERDYNAMIC DT 1770 PRO

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Windows 10

AMD

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Cortana available in select markets at launch, experience my vary by device.

*External monitor must support HDMI input [If continuum-compatible accessory is not included, add: "Accessories sold seperately."] **App availability and experience varies by device and market. Office 365 subscription required for some features. 1Limited to select premium phones at launch. Feature and app availability and experience may vary by market and device. Windows Hello required specialized hardware, including fingerprint reader, illuminated IR sensor or other biometric sensors.

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TALKING

BY **ZAK STOREY**

Mionix Lays the Peripheral Industry Bare

Carl Silbersky and Chris Suess give their insights

Without the mouse, our computing experiences would be very different. There's a model for everyone, and a style for every shape of hand. However, the industry is under a lot of scrutiny. We spoke to Carl Silbersky, CEO at Mionix, and Christoffer Suess, VP of marketing, to understand how they go about the design process, what prompted them to add a GSR and heart rate sensor to the latest Naos, and where they think the industry is heading.

Mionix's CEO and investor, Carl Silbersky, gives us his take on the peripheral industry.

Maximum PC: Can you tell us what exactly prompted you to integrate a heart rate sensor into a mouse?

Carl Silbersky: If I take a step back there for a moment, I would say that I didn't come from the hardware industry—that's the first thing. And my observation, when I first came to Mionix, which was two and a half years ago, was that I just laughed at the whole hardware industry. Like, Jesus, what's happening here, you know? Where's the innovation? What's been happening in the last 10 years with gaming hardware? I mean nothing, basically nothing. I mean, what we've *[peripheral manufacturers]* done is we've put bears, and snakes, and things like that on the mice, and we call them gaming peripherals. And then, suddenly, we tried to shove—well, they've been trying; I mean, Chris here has been very successful, when he was at Razer—a snake down into a 14-year-old's throat. I mean, you did this very successfully, Chris, I have to give it to you.

Anyway, it was seen as obscure people who used to game—that's how it used to be viewed. And from my vision, when I came, I was like, gaming is completely exploding, and it's what we are all going to do. I mean, when you look at Steam, it was going through the roof—it's going to be a natural thing, what we're all going to do, gaming in one way or another. And when I looked at the peripherals at hand, the basic peripherals, which we're trying to fix here at Mionix—the mouse, the keyboard, the headset—I was like, OK, what has happened? Nothing. So we started with that: OK, nothing has been happening, so let's at least try to get the basics in there. The basics for us, you call innovative; for us, it's like, of course there should be a heart rate sensor in there. And the thing is, I think what I missed, and what we're completely open with, was that, OK, so I'm watching somebody gaming, which we all love, when we get together at Mionix. We looked at Twitch, and were like, wow, this is going to really take off. It's entertaining, it's more fun than a lot of the sports displayed in the world, and you can interact with the gamer etc, etc. But why can't I see the actual reaction of the person when they're playing *Dead by Daylight*, or whatever? So that was one reason.

The second reason was actually that we did hack at it in the office, when we looked at, y'know, what can we add to these mice, and what came out of it was that we had this idea like, let's add a layer, so I can actually see someone, and see what their reaction is when

The Mionix Castor made waves with its fantastic ergonomic design.

they're gaming, and that's when we started to integrate sensors into the mice. And one thing lead to another thing, and we said, you know, we should have a GSR sensor in there as well, so you can overlay, and see their reaction in gaming. But I think what you're going to see from us is that there's so much more to be done, there's so much still missing for us. For me, this is basic, this is what we needed, this should have been done—why hasn't anybody else, with a budget that's probably 10 times the size of ours, like Logitech, which is 20 times bigger than us, done it? Where have they been for the last 10 years?

MPC: With all that in mind, then, who is the Naos QG mouse aimed at? Is it solely the Twitch streamers? The YouTubers?

Carl: This is the way we look at it: they're streamers—but, actually, they're creative people. The streamers we like are entertainers, you know? Like Pewdiepie—he's an entertainer, isn't he? Is he a gamer? No—he's not a fantastic gamer. But I want to see, when I watch somebody stream, someone who entertains me. I want to see a reaction from them, and this is a great layer for someone to display their reaction on. So, it's for the creators; it's for the streamers to start with, I would say.

Secondly, it's for the group of people, like esports people, who want to get super-hardcore data, and crunch data when they're gaming. Or even poker players, who we're getting a lot of interest from.

So, first, it's the creators, the streamers, who want to display what they're doing, and want to show off and create entertainment value, and make people understand. Then, the second market is the poker players, the gamers, the esports people, who just want to understand—the more serious data-crunching people.

MPC: Speaking of the heart rate sensor in particular, is that something that's proprietary to Mionix, or will you be opening that up to other peripheral manufacturers?

Carl: Let me say it like this: We've started some discussions, and people have reached out to us—a very interesting group has reached out to us, in fact—and we might be considering something. If you're asking whether we will go deeper into other areas, and collaborate, then, yeah, maybe. We'll see where this leads us. But the more interesting part is that we have a set of open APIs, so developers can actually use them, and integrate them any way they want, in any gameplay, or whatever they want to do with them—they can make use of those open APIs. I can say this: Several universities came to us, and asked us to do research things with them. We thought that was super-interesting, and that lead to another thing, which lead to another thing, and now we're having some pretty interesting discussions.

> The basics for us, you call innovative; for us, of course there should be a heart rate sensor in there

Chris Suess: What we can say is that we were actually approached by one of the other peripheral manufacturers, right, but we have not decided how to handle that. Interest is there from other parties, but without going too much into detail, it's an open discussion.

Carl: Chris, I've said too much, but we have the other manufacturers, as we've said, we have the universities, which is for research, we have game developers, and we have open APIs. So, for us, it's open as to where we're going with this.

MPC: So, it sounds as though you're looking to innovate not only at Mionix, but also across the entire industry?

Carl: To be honest, I don't even know what Mionix is. Are we a hardware company? Yeah, today we're a hardware company. What are we tomorrow? Well, you know, we might not just stay true to hardware.

MPC: OK....

Carl: So now you're going to get even more confused, because, er, yeah... But it's true, what we're doing is not just, "Oh, let's just bring out another piece of hardware." I think the world has a lot of pieces of hardware, so let's see where we can go with this, and where that leads us—that's our interest. We're weird, I know we're weird, I know you're going to perceive us as weird.

MPC: Not at all! But, pushing the Naos QG aside for a moment, how do you go about mouse design in general? Where do you start with that?

Carl: It starts with an idea and a shape for purpose. We want to create mice that, regardless of grip, can serve people while resting the fingers—usually right-handed mice. That's the idea we had from the starting point, and from there on, it's a process. The whole design goes into process, and we've been famous over the years for creating great ergonomic mice. It's almost a shame that, with the size of the company when we took it over, and given the products Mionix produces, up until then it only had the Naos and the Avior. It was a shame, because I thought they were fantastic pieces of hardware. They had not been recognized for their ergonomics. So, when we created the Castor, we went after a specific ID for a specific kind of mouse. Then it starts to go into an iterative process of shaping and reshaping, again and again, and it's actually physical work, like craftsmanship. You sit down with a block, and then you iterate that one over, and over, and over, and then you have people coming in and feeling it, and understanding. And saying, "No, I want this, and this, and this."

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> All-In-One Upgrades
> PSU Madness
> Xeon vs. Core i7

RM 750x
CORSAIR

A 750W PSU is more than ample for most high-end PCs with efficient CPUs and GPUs.

Upgrade All-In-One?

Hello Doc, I know that all-in-ones are difficult to modify, because of their size, thermal, and power constraints. But do you think it would be possible to upgrade my HP Envy 23 d038c, dropping in a new GPU, and maybe SSD? I want to play *Battlefield 4* and *1* at 60fps on at least Medium quality. I discovered that the motherboard has two second-gen PCI Express mini-card slots, and a PCI Express MXM slot that supports a 16-lane graphics card. So, would it be possible for me to fit in a low-profile $100-250 GPU and an SSD, without needing to buy a new case/board? I should expect to need a new PSU though, right? **–Charlie**

THE DOCTOR RESPONDS: Unfortunately, without knowing your current specs, it's hard to say how much you'd gain from an upgrade. Then again, the H61-based motherboard HP uses is fairly flexible. For instance, there are 13 different host processors approved for use on it, including third-gen (Ivy Bridge) Core i7 CPUs rated for up to 65W. If you're currently using a dual-core or older Sandy Bridge-based chip, that's one possible avenue for extra performance. Two memory slots pave the way for up to 16GB of DDR-1600 memory—but only if you drop in one of those third-gen Core CPUs. The generation prior only supported 4GB SO-DIMMs, capping you at 8GB total.

Now here's the bad news. Although the Envy 23 does have an MXM 3.0 Type A slot, HP specifies that whatever you drop in has to be under 35W. It's difficult enough to find MXM cards for sale (these aren't just low-profile graphics cards, but rather laptop-oriented modules). But a 35W ceiling is virtually unheard of. And anything you do find won't be fast enough for *Battlefield.*

An SSD is certainly more plausible. From the factory, two available SATA 2.0 ports connect to one hard disk, and the Envy's SuperMulti Blu-ray player. You could replace the mechanical drive with solid-state storage for quicker response times, though that old SATA interface will bottleneck peak throughput to under 300MB/s.

In the end, HP's older all-in-one is great for productivity and convenience. It's not a gaming platform, though. And while you have some upgrade options, that money would be better spent on hardware for a real *Battlefield*-worthy PC.

Tracking Down a TPM

Hello, Doctor. The release of Microsoft's Windows 10 Anniversary Update includes the mandatory requirement of a TPM 2.0 module to enable new security features. I have an Asus Maximus VIII Hero motherboard (running BIOS version 1902), with a 14-1-pin TPM connector. When I search Asus's website, I find other people asking this same question: Where can I find the 14-1-pin module compatible with Asus's Maximus VIII Hero? Moreover, can you describe what new Windows 10 security features desktop users are getting? Finally, if my system doesn't have the required TPM 2.0 module, will the Anniversary Update still install? **–Phil Carlson**

THE DOCTOR RESPONDS: The Doc found listings for Asus's 14-1-pin TPM module on Amazon, eBay, B&H, and even Walmart's website. They may have been hard to come by earlier in 2016, but availability appears plentiful as the year comes to a close.

As for the role TPM 2.0 plays in Win 10 Anniversary Update, it's all about security. BitLocker (full disk encryption), Measured Boot (a log for verifying the integrity of a client system's boot state), Credential Guard (a feature related to Virtual Security Mode for managing credentials), and Virtual Smart Cards leverage Trusted Platform Module capabilities to keep sensitive data isolated.

Windows Hello adds facial and fingerprint recognition to sidestep the vulnerabilities commonly associated with compromised passwords. And while a TPM isn't required to

↘ submit your questions to: doctor@maximumpc.com

All-in-ones are great for convenience, but their form factor makes upgrades tricky.

use Hello, your authentication information is best protected by hardware. Just be aware that Hello works with biometric sensors attached to your PC, which may require some additional investment.

You should have no trouble installing the Anniversary Update, even without the TPM.

Will It Play Nice?

I'm not sure if these parts are compatible. Will they play nicely together at the playground? My shopping cart includes an Intel Core i7-6700K, MSI's Z170A Mpower Gaming Titanium, a DDR4-3466 Corsair Dominator Platinum kit in four 16GB modules, an Asus GeForce GTX 980 Ti Strix graphics card, two 512GB Samsung 950 Pro SSDs, and Be Quiet!'s Dark Rock Pro CPU cooler.

–James Dodson, Psy.D.

THE DOCTOR RESPONDS: Are all of those parts compatible from a technology standpoint? Yes. Does the Doc think they represent the best balance for your money? Not necessarily. Will you probably run into clearance trouble with those memory modules and that cooler? It sure looks like it.

MSI's Z170A Mpower Gaming Titanium is one of the pricier LGA 1151-equipped mobos, so the Doc assumes you chose it for its exotic looks, which you'll show off prominently in a windowed case. Fair enough. Intel's Core i7-6700K is a solid pick at the top of its Skylake-based stack, so no argument there. And the Dark Rock Pro 3 is an attractive air cooler with serious performance chops.

Unfortunately, Corsair's Dominator Platinum modules are incredibly tall. Coupled with Be Quiet!'s heatsink, the Doc would worry about a height incompatibility. Even if the pieces did fit together, you'll see little benefit from a $500-plus DDR4-3466 kit. Spend under $200 on a lower-profile 32GB kit, and pocket the difference.

You can also do better than that Asus GeForce GTX 980 Ti. For $50 less, any number of GeForce GTX 1080 8GB cards deliver double-digit performance gains. Or snag a GeForce GTX 1070 serving up similar frame rates as the 980 Ti for closer to $400.

As for storage, nobody will argue against the potency of two 512GB 950 Pros. But consider a big mechanical disk in some sort of redundant array for your movies, music, and photos, too. Alternatively, networked or cloud-based storage would work. Just make sure those important memories and media files are protected against failure.

Stop the PSU Madness

Doc, I've noticed a trend of people believing they need larger power supplies than they do, then recommending the same to others. In the November edition of *Maximum PC*, you answered a reader's question regarding his power supply. You stated a PC pulling 500W with a PSU rated for 1,000W would pull 555W from the wall, whereas a PSU rated for 725W would pull 625W. But you compared an 80 PLUS Gold 1,000W PSU to an 80 PLUS (not Gold, or Silver, or even Bronze) 725W PSU, which isn't fair. An 80 PLUS Gold PSU should be 90 percent efficient or better at 50 percent load, and 87 percent efficient or better at 100 percent load. An 80 PLUS Gold 725W PSU will be at about 70 percent of rated load, so probably 88 percent efficient. So an 80 PLUS Gold 725W PSU will be drawing 568W, not 625W.

I see similar comments when people ask about upgrading video cards. The answers they receive suggest at least a 750W PSU to drive one GeForce GTX 970 and a Core i7-3770K, when a 450W PSU is more than enough. This trend makes folks believe they don't have the headroom to upgrade, even though they do. For example, your mid-range build calls for a 650W PSU, when the components only pull 327W.

When considering power supplies, I usually estimate how much power my components will use, then add 20 percent for margin. That keeps my PSU within its limits, and my components on budget. A good PSU can operate up to its limit for a long time with no issues.

Leaving room for future expansion is fine; encouraging people to overbuy their PSU (or not upgrade hardware because of it) is not. Waste heat and losses due to inefficiencies are negligible in good power supplies. Please help stop the madness. **–AJ Starling**

THE DOCTOR RESPONDS: What makes the comparison unfair? Both PSUs in the Doc's example are purely hypothetical, and the math works out. A 1kW 80 PLUS Gold PSU feeding a PC 500W is about 90 percent efficient at this 50 percent load, pulling 555W from the wall. The 750W 80 PLUS example feeding the same 500W is about 80 percent efficient at 67 percent load, pulling 625W from the wall.

Obviously, changing the 80 PLUS efficiency rating affects what's lost to heat. Give both made-up PSUs a sexy 80 PLUS Titanium rating, jack up their prices by $100, and suddenly the 1kW PSU only pulls 532W from the wall, while the 750W model is closer to 545W.

Not to take away from the point we both were trying to make: It's important to strike a balance. Weigh the needs of your components, add some headroom to avoid running at 100 percent load (leaving room for future expansion at the same time), and decide how much extra you're willing to pay for high efficiency.

Xeon vs. Core i7

Dear Doctor, We've been reading *Maximum PC* for almost a year, and have learned a lot, but we still have questions. We need a powerful computer for working in Avid Pro Tools 11 and Avid Media Composer 8. We want to build a powerful PC, but don't know the difference between Intel's Xeon and Core i7 families.

For the Core i7 build, we'd pick between a 5960X or 6950X, a 512GB Samsung 950 Pro for the OS, a 500GB 850 EVO for the sound library, two WD Black 6TB drives for data, and a GeForce GTX 1080 Founder's Edition. If we went with a Xeon, we'd choose an eight-core E5 with 25MB of L3 cache. Can we still use an X99 motherboard and regular DDR4 RAM? If not, what do we need? Would this be better than a Core i7?

–Anthony & Julia Shepard

THE DOCTOR RESPONDS: In truth, Core i7s and uniprocessor Xeons (like the latest E5-1600 v4 line-up) are architecturally identical. The Core i7s support overclocking through unlocked multipliers, though, while the Xeons accommodate ECC memory, enable vPro, and allow you to install more than 1.5TB of RAM. Many X99-based motherboards do support Xeon E5-1600 CPUs, but if you need tons of memory, you'll want to find a platform with Intel's C612 chipset on it instead. ⏻

Windows 10

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TODAY'S BEST UPGRADES

What hardware to upgrade in your ageing machine, and when

THE CONCEPT OF THE UPGRADE PATH is at the very core of the hardware enthusiast's philosophy. The notion that you can take a five-year-old system, throw out a few parts, install a few new ones, and have a rig up and running—which almost competes with a brand new build—in less time than it takes for Obama to drop the mic is certainly appealing. But how far does it go in practice? What makes the biggest difference? And what should you upgrade first?

This month, we decided to find out. We took two case studies, two rigs gathering dust in the corners of our office: one a gaming system, the other a workstation. And then we chose two very different upgrade paths for them both, just to see what makes the biggest difference to overall performance in their respective fields.

The first system was an ageing workstation. Featuring a mighty Core i7-970, this bad boy was Intel's second venture into six-core processors—and coming in at 3.2GHz and $885, it was no slouch. Coupled with a thwomping 6GB of DDR3 1600, a singular 2TB SATA II HDD, and a powerful ATI HIS HD 5870 graphics card, it was a monster in its heyday. Six years on, however, its hard drive is sluggish, the processor on a par with a modern Core i5, and its motherboard support simply laughable. In the other corner is our gaming rig. Far younger than its sibling workstation, this one had fared a bit better over the years. Featuring an Intel Core i5-4670, the Haswell monster still had plenty of computational power to muster—with 8GB of RAM, a 256GB OCZ Vertex 4 SSD, and a reference GTX 670 pumping those frames, you could still game at 1080p, albeit far below the minimum 30fps in most cases.

So, if you're curious about what you should upgrade next, and whether it's worth it, or you just want to take a look at what we did to bring these mature machines back to life, read on.

SAMSUNG
Solid State Drive
CORSAIR
DOMINATOR
PLATINUM
DDR4
3200
MHz
V336 VER:3.0
PRODUCT OF CHINA

PRACTICAL ADVICE FOR UPGRADING

THERE ARE PLENTY OF REASONS why we upgrade. They can range from the essential to the vain, from the aspirational to the vital. An upgrade may allow you to hit better frame rates in your favorite games, or give your system enough raw grunt to tackle a title that it couldn't before. If you use your machine for more serious work, an upgrade may allow you to get more done in a shorter space of time, or even do things that you wouldn't have been able to do with your current system.

A reasonable rule of thumb is: If you find yourself waiting for your machine to finish a task, then it could probably do with an upgrade. Whether that's rendering a video, applying an effect to an image, booting, loading an application or website—anything at all, really. Your time is precious, so don't squander it waiting for a machine to complete a task, when technology is there to help. And it doesn't have to be a hardware upgrade that you need; turning to better software, or tweaking the software you're already running, could also be an option—but we'll come on to that shortly.

Of course, there tends to be something holding most of us back when it comes to pulling the trigger on constantly upgrading, and that's the cost. Weighing up the benefits against the price tag is just as important as working out what those hardware updates should be. If your budget can extend to getting the very best component in each category, then all power to you, but most of us can't afford to maintain such an aggressive upgrade regime. If you know that you're going to have to change out several vital components, then planning your upgrade makes sense—buying a graphics card that will still be relevant when you change up your processor and motherboard later.

Knowing what you want from an upgrade is key, because without that knowledge, you're just chasing the next biggest and brightest thing, without taking stock of whether it actually makes sense. Working out what you want to do also enables you to focus on the component or subsystem that will have the greatest impact. Quite often, only you can really know what that area is.

For instance, we wouldn't normally recommend that you spend your time and money upgrading your memory, because for the vast majority of uses, 8GB is enough (or even 4GB, if you're dealing with a much older machine). However, if you're multitasking a lot, editing multiple 4K images, and messing around with UHD video, then doubling up to 16GB or even 32GB could reap real benefits.

msi
Z170A TOMAHAWK
DDR4 BOOST
msi

Aim for a platform, and reap the benefits of the latest tech.

PROCESSORS

Your CPU is at the heart of pretty much everything you do, so there's a certain logic in coveting the very latest processor architecture, and seeing that as the magical panacea to all your computing woes. The problem with this train of thought is that more recent CPU upgrades have been fairly subtle in real terms. In fact, the last few generations have seen raw performance increase by just 10 percent. So, if you miss a generation, there's not too much to get upset about. Miss a few generations, though, and those figures add up (such increases are cumulative).

We haven't seen any major shift in core counts for mainstream processors, and the frequencies have been creeping up reasonably slowly as well. So, even if your CPU is a few generations out of date, that's no guarantee that a CPU upgrade will transform your PC. Indeed, as we found in one of our case studies over the page, a decent CPU from quite a few years ago can still stand its ground against newer chips in practical terms.

There is a fairly major caveat here, though, which is that newer processors support newer technologies, aka the chipsets, and in terms of the bigger picture, this could make a CPU and motherboard upgrade a far more attractive option. M.2 NVMe drives, for instance, can hit transfer rates of 3.5GB/s, as opposed to a lowly SATA SSD, which sits at a meager 550MB/s.

INTEL CONFIDENTIAL
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QKVN 3.00GHZ
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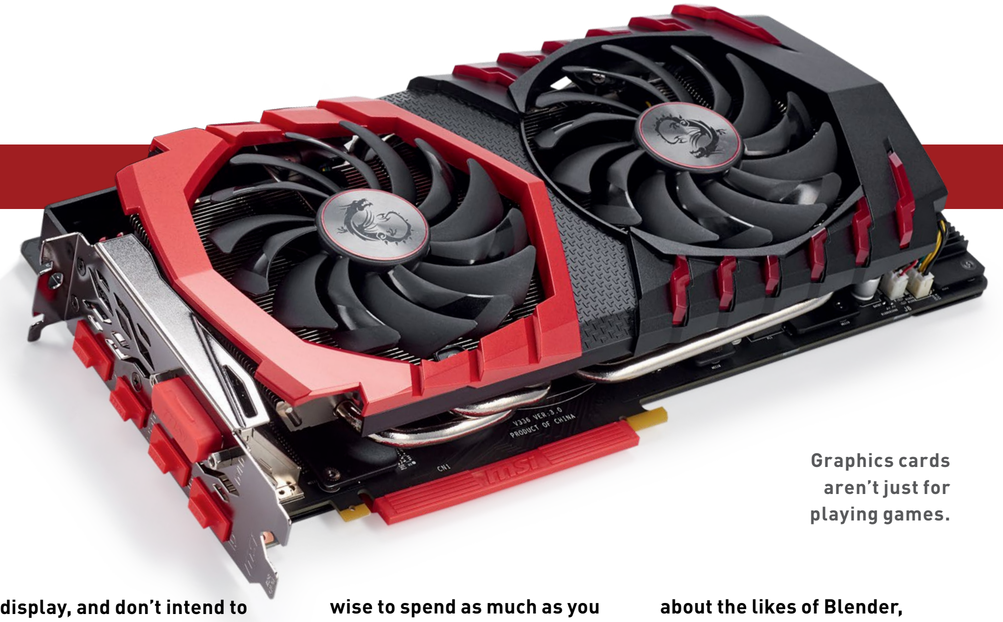
Upgrading your CPU isn't about buying the most expensive chip out there.



Graphics cards aren't just for playing games.

GRAPHICS CARDS

If gaming is something that interests you, you need a graphics card. If you want to play the latest games, you need an up-to-date graphics card. That's pretty much the long and short of it. If gaming is lower down on your list, you probably don't need to upgrade—in fact, you might be able to get away with the integrated graphics capabilities of your CPU. As we say, knowing what you want to use your machine for is key.

As ever with graphics cards, you need to keep your target display in mind when looking at upgrades. There's not a lot of point dropping $800 on a GeForce GTX 1080 if you're happy with your standard HD display, and don't intend to upgrade it any time soon. Buy a graphics card that can drive your display(s), it's that simple. We run plenty of graphics card group tests to help you make the decision on what graphics card is right for you, but just as with the processor market at the moment, there's a good correlation between price and performance—if you're serious about gaming, then it's wise to spend as much as you can to get the performance you need for today's and tomorrow's titles.

Again, there's a proviso, which is to do with using a graphics card for more serious work. Some applications can take advantage of the processing power of a graphics card using CUDA or OpenCL to improve performance significantly—we're talking about the likes of Blender, Maya, and Sony Vegas, among others. The problem is knowing which applications you use actually take advantage of which cards, using which API, and ultimately to what benefit. Check out the software developer's website for the application you're utilizing, to see if there's any advantage to using a specific graphics card.

STORAGE

While processors and graphics cards get the most love in any upgrade decision, they're not the only areas of your system that you should be considering. In fact, we would suggest that another component should be the focus of your passions nowadays, and here we're talking about storage. If you're looking to make just one upgrade in your machine, then upgrading to a modern, speedy SSD will make a tangible difference to pretty much everything you do.

Yes, we know that it isn't traditionally the sexiest bit of computing, but the difference storage can make to how you use your machine can be as obvious as the difference between night and day. This is particularly relevant if you're rocking a spinning hard drive as your main boot device, but also true if you're going from a first- or second-generation SSD up to a modern NVMe M.2 drive. This in turn may require an upgrade to your system's motherboard, which could lead to a new processor, new memory, and more, so as ever, it comes back to what you actually use your machine for.

Do yourself a favor—upgrade to a modern SSD.

There's still a place for spinning storage in modern PCs.

CASE STUDY: GAMING

SO HERE SHE IS, our upgraded gaming machine. From the get go, she came packed with a quad-core processor, 8GB of DDR3, a slightly ageing OCZ 256GB SSD, a 1TB hard drive, and the powerhouse that was the GTX 670. Boy, those were the days, huh? Not too old, we know. This machine was pieced together back in 2013, making it, relatively speaking, still fairly new. And it shows—the motherboard at the rig's heart is still sound. There's an M.2 slot offering up to 10Gb/s transfers, plenty of PCIe slots for additional cards, support for up to 64GB of DDR3, and even onboard power buttons.

Aim of the Upgrade

So, the story behind this system was fairly simple: We assumed that the gamer in question was on a tight budget, they didn't have a lot of cash to throw around, and had only managed to save up for the occasional lump of hardware here and there since it had been originally built. The last and biggest bundle being the motherboard, processor, and GPU combo.

The case was old, probably taken from an office PC from years ago, or a tower the grandparents had used for a while. The power supply was also old, and the storage was somewhat wanting. So, ultimately, we kept it simple and just upgraded the memory capacity and the GPU. Upgrading from Nvidia's GeForce GTX 670 to the GTX 1060 would not only reduce the power draw overhead from the GPU, but also improve frame rates by well over 100 percent.

The Intel Core i5-4670K is by no means the bottleneck in this system—certainly not yet, anyway—but we decided to throw out the old memory in favor of something a little more impactful. So, we grabbed two sticks of 8GB DDR3 to ensure that we could both game and run programs from the desktop without worry.

Free Upgrades?

There's a variety of things you can do to eke out extra performance here and there in a gaming build like this. Keeping your drivers up to date is essential if you want to improve performance. An unoptimized game can benefit by as much as 20–30 percent, purely from a driver pass. Couple that with a gentle GPU overclock, and you can easily crank those frames back up when you begin to experience problems.

Another cheap fix is to increase the number of fans in your build. GPU Boost 2.0 automatically increases the core clock of your graphics card, dependent on the overall temperature, so throwing a couple of extra fans in the front of a chassis, or even on a ventilated side panel, should help keep your card cooler, and let it overclock higher.

However, if you're concerned that your processor may be holding back your GPU, you can throw the multiplier up a fraction to see if that can alleviate the problem. If you're running a stock cooler, as we are here, we suggest leaving the voltage alone entirely, and adjusting the multiplier by two or three at most.

CrossFire Conundrum

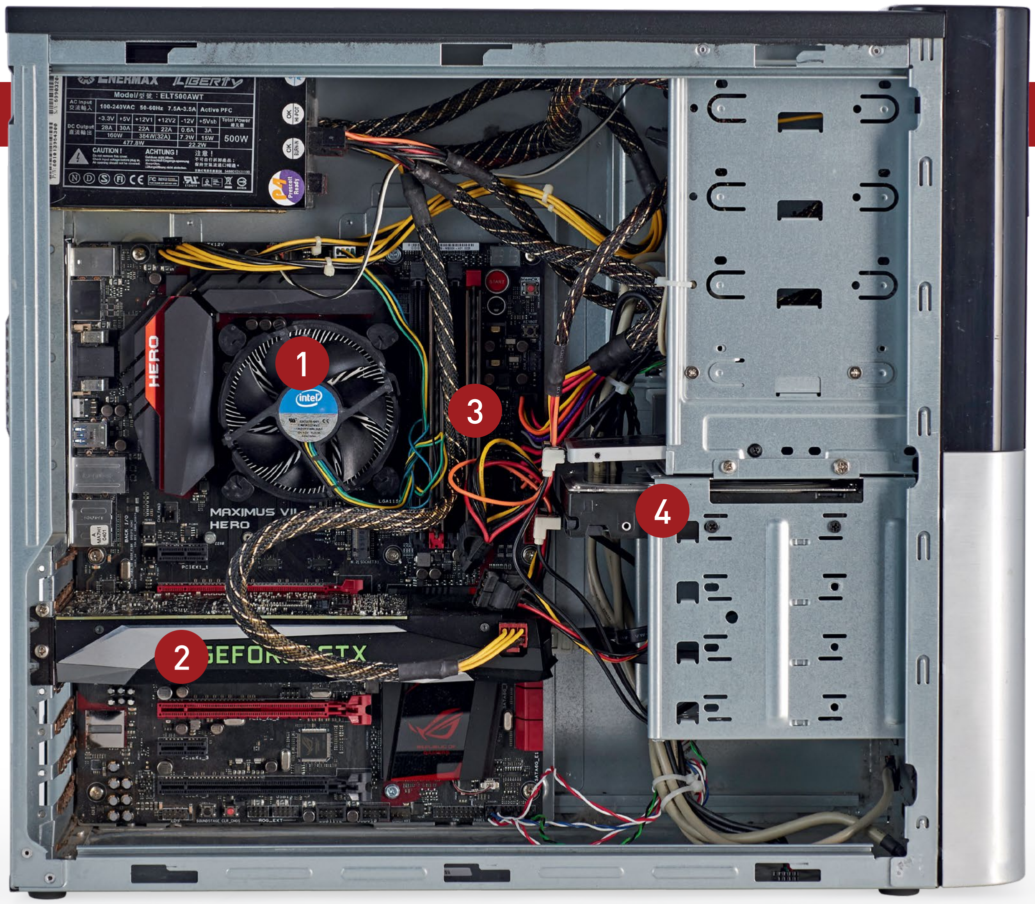
An alternative to purchasing a new GPU is to opt for a second older card instead, usually within one to two years of purchasing the first, if you can find one. This can be a good solution to save a few dollars, but it's not without its setbacks. Firstly, SLI and CrossFire profiles aren't always perfect. Generally speaking, on game launch, most titles simply don't have support for any multi-GPU configurations. Which means your second card immediately becomes a paperweight. On top of that, it's likely that you'll end up with trouble in the power supply department as well, if you're not careful, because you can easily add an additional 200W of power draw simply by adding the additional card. On the other hand, getting a more powerful card the first time around, or a newer generation of GPU, will lead you to guaranteed better performance, and better power savings in the long run.

GEFORC
GEFORC

Double or nothing? Two GPUs can yield benefits, but they also increase your power draw.

SPECIFICATIONS

	Base	Upgrades
Processor	Intel Core i5-4670K	
Memory	8GB (2x 4GB) Corsair Vengeance DDR3 @ 1,600	**16GB (2x 8GB) Crucial Ballistix Tactical 1600** *($91)*
Motherboard	Asus Maximus VII Hero	
GPU	Nvidia GeForce GTX 670 2GB	**Nvidia GeForce GTX 1060 6GB** *($299)*
Storage 1	256GB OCZ Vertex 4	
Storage 2	1TB Hitachi 5,200rpm HDD	
Cost		**$390**



1 CPU Ultimately, we decided to forego upgrading the processor. The Intel Core i5-4670K inside this machine holds more than enough potential to handle any game or program we can throw at it. And if we really need to, we can swap out the cooler for something chunkier, and crank those hertz up.

2 GPU Swapping from a GTX 670 to a GTX 1060 made a whole world of difference. We opted to go for the 6GB reference variant in the end for this build, but the frame rate difference between that and the 3GB version really isn't catastrophic. We saw an overall increase of almost double in every game.

3 Memory Upgrading from 8GB to 16GB of DDR3 for this build was purely a quality-of-life procedure. Having access to more memory gives us the opportunity to run VOIP clients, Google Chrome, and recording software, all while running some of the more demanding AAA titles out there.

4 Hard Drives All things considered, the storage situation was pretty sound from the start. A 256GB OCZ Vertex4 is still quite a competitive drive, and backed up by that 1TB drive, it covers all your bases. We would have loved to have changed to a PCIe drive, but for a gaming system, it's not entirely necessary.

THE RESULT

Well, it was always going to be a sure-fire victory for the GPU. The Intel Core i5-4670K is still an extremely competitive core. In fact, unless you're running anything pre-Sandy Bridge, you're unlikely to reach any bottlenecks with regard to gaming and graphical limitations. If this system was going to be sitting in the office for much longer, we would definitely take a look at swapping to a more modern chassis, and potentially go for a newer power supply and better cooling, too—just to reduce noise and for peace of mind. That said, this is a system more than capable of gaming at 1080p and beyond. Not bad for an outlay of just under $400.

BENCHMARKS

	BASE SYSTEM	
Cinebench R15 (Index)	570	568 (0%)
Aida64 Memory Latency (ns)	75.3	73.7 (2%)
CrystalDisk Sequential Read (MB/s)	536	543 (1%)
CrystalDisk Sequential Write (MB/s)	526	527 (0%)
3DMark Fire Strike (Index)	5,735	10,156 (77%)
Far Cry Primal (fps)	35	66 (89%)
Total War: Attila (fps)	18	37 (106%)
Rise of the Tomb Raider (fps)	20	40 (100%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

All games were tested at the maximum possible preset, with HD texture packs turned on. Scores represent average frames per second in those titles, unless otherwise specified.

CASE STUDY: WORKSTATION

THIS IS BY FAR the more interesting build. In fact, its ancient and decaying spec sheet was still far more intriguing than the updates that followed. With one of the world's first six-core consumer processors, 6GB of DDR3, and a prestigious Intel motherboard (yep, it still made them), this system managed to crank out some serious numbers even today, six years on. The hard drive situation was far less desirable—with two SATA II HDDs, it was mostly used a web server, before finally being retired two years ago. Last week, it was a shelving unit. So, what did we manage to salvage?

Aim of the Upgrade

This was the biggy. We knew we wanted to upgrade to a more modern chipset. But a more modern chipset requires a brand new motherboard, and a new mobo requires a new processor, which requires new RAM. Like a cascade effect, upgrading one part meant that pretty much everything had to change. We opted to grab an Intel Core i7-5820K to replace the ageing Gulftown processor—it's cheap, packed with additional PCIe lanes for future upgrades, and supports the latest X99 motherboards. Then we had to decide on the memory, upgrading from a tri-channel 6GB kit of DDR3 all the way up to a 32GB kit of quad-channel Crucial Ballistix Elite.

Motherboard-wise, we decided to go for the EVGA X99 Micro 2. It looks crisp and clean, it performs well, and it fits into our shiny new case well, too. On top of that, it gives us plenty of expandability going forward, enabling us to install two add-in cards if needed. We also fitted a 240GB Kingston HyperX Predator M.2 PCIe SSD—not the fastest of the PCIe SSDs, but it's cost effective, and easily knocks the old SATA II drives out of the park.

Free Upgrades?

There are a couple of free options on a setup like this. We took the old 2TB SATA II drives, and configured them to operate in RAID 0 to boost sequential read and write speeds. To do this, go into your motherboard's BIOS settings, find your SATA configuration panel, and change the storage type from AHCI to RAID. Upon restarting, hold Ctrl, and press I repeatedly to get into the RAID menu. Select the drives you want, choose the RAID setup you'd like, and create away. If you're using RAID 0, it should double your potential sequentials; and if you're using RAID 1, it mirrors the data on to the second drive, so if one drive fails, you always have an accessible backup.

Then there's overclocking. Far more useful for rendering tasks on workstations than on gaming PCs, bumping the Core i7-5820K up to 4.2GHz is relatively easy, and shaves off a significant amount of time from your render cycles.

Pump Up the PSU

For this build, we opted not to swap out the graphics card. As it's not gaming PC, but a content creation workstation, it was unnecessary to move away from a high-end card like the 5870 to something more modern, at least until we start using CUDA for rendering. That said, we had to consider that our operating requirements were going to change dramatically in contrast to the old Gulftown rig.

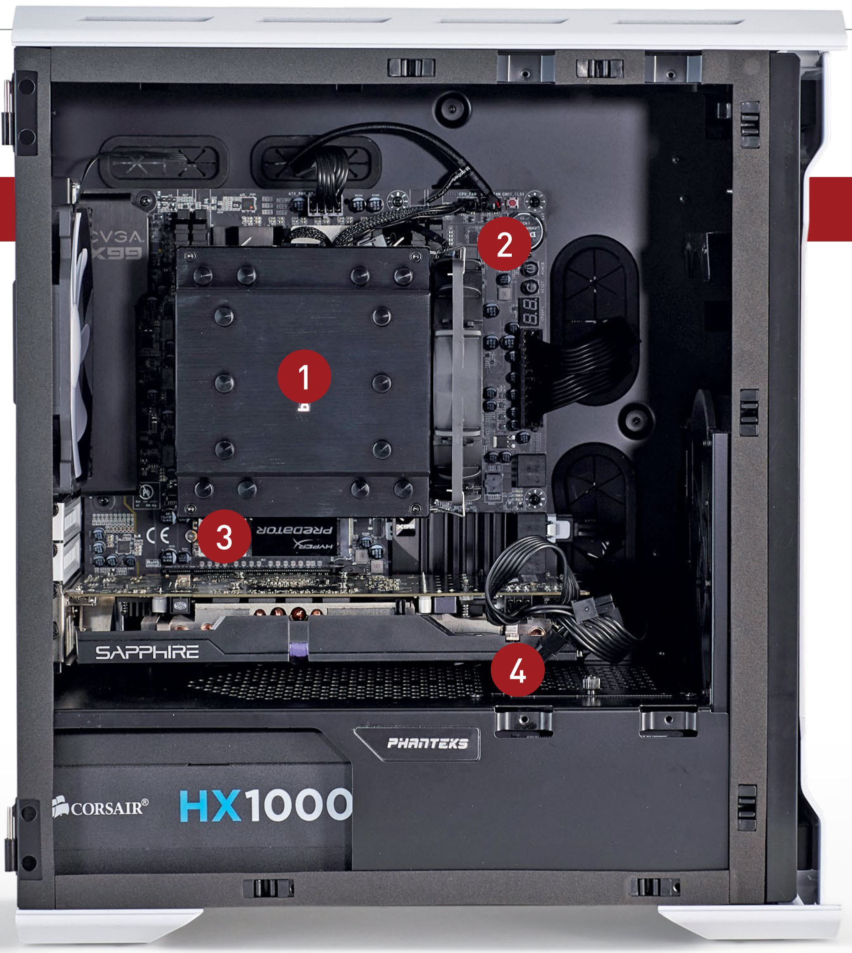
Using Pcpartpicker.com, we specced up the requirements for our new upgraded system (including older GPUs and hard drives), which provided us with a good estimate of what our overall power usage was going to be (471W at peak). You should always look for a power supply that provides somewhere in the region of 20–25 percent more rated power than your system draws from the wall. That way, you'll never run it at max capacity, and PSUs are generally most efficient when they run at 80–90 percent capacity.

CORSAIR
HX1000i
CORSAIR LINK DIGITAL

Ensure your PSU is rated to provide about 25 percent more power than your system draws.

SPECIFICATIONS

	Base	Upgrades
Processor	Intel Core i7-970	**Intel Core i7-5820K** *($390)*
Memory	6GB (3x 2GB) Patriot DDR3 @ 1,600MT/s	**32GB (4x 8GB) Crucial Ballistix Elite DDR4 @ 2,666MT/s** *($220)*
Motherboard	Intel Desk Board	**EVGA X99 Micro 2** *($193)*
GPU	ATI Radeon HD 5870	
Storage 1	2TB Western Digital SATA II	**240GB Kingston HyperX Predator M.2 SSD** *($146)*
Storage 2	2TB Western Digital SATA II	
Misc		**Case, PSU, CPU cooler** *($380)*
Cost		**$1,329**



1 **CPU** The CPU was the second-biggest change we made to this system. Jumping forward by five generations of processor technology has helped to push performance up by almost 35 percent in contrast to the Intel Core i7-970 that was originally found in this machine. A very worthwhile upgrade.

2 **Motherboard** And now the biggest change we made: the motherboard. Not only did we opt to go with an X99 board this time around, but we also swapped over to microATX in the process. This means we can choose a smaller, more versatile chassis, yet still retain all of the power of the X99 socket.

3 **Hard Drives** Another massive change for our workstation is the upgrade from the ageing SATA II hard drive to the modern powerhouse of a PCIe SSD. Although it's not the fastest SSD drive out there, the HyperX positively warps space when you compare it to its spinning predecessor.

4 **GPU** Simply put, this isn't a system for the gamers—it's a system for the designers, the CAD developers, the artists, the videographers, and the photographers. An expensive GPU simply isn't necessary. Could it be used for gaming in the future? Of course, but for the time being, it's far from essential.

THE RESULT

As you can see from the benchmarks, the biggest performance increase stemmed from the hard drive swap. Going from SATA II drives to a PCIe SSD, and using the SATA drives as backup storage is nothing short of incredible. Interestingly, after five years of processor development, Intel's six-core enthusiast chip only beats the Intel Core i7-970 by 35 percent. What's important to note is that the price has plummeted.

Other than that, this upgrade came together nicely. The HD5870 was still more than enough for all the editing we wanted to do. In the long term, however, it might have been nice to change out to a GTX 1060 or RX 480 instead.

BENCHMARKS

	BASE SYSTEM	
Cinebench R15 (Index)	750	1016 (35%)
Aida64 Memory Latency (ns)	70.5	70.6 (0%)
CrystalDisk Sequential Read (MB/s)	132	1,573 (1,092%)
CrystalDisk Sequential Write (MB/s)	131	995 (660%)
CrystalDisk 4K Read (MB/s)	0.7	37 (5,185%)
CrystalDisk 4K Write (MB/s)	1.2	103.7 (8,542%)
PCMark 8 Home (Index)	3,249	3,937 (21%)
3DMark Fire Strike (Index)	2,837	2,844 (0%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

All benchmarks are run three times for consistency, and an average is taken. CrystalDiskMark scores are actually correct.

OTHER TWEAKS AND TRICKS

Chassis are slowly turning into works of art.

CASES

You could say a case is nothing more than six panels of metal holding the components of a system together. In reality, it's much more than that. Cases are an essential part of PC building. Whether you build your own, pinch one from an age gone by, or go all-out and purchase a $400 affair, it's something that every PC user has. But how much of an impact does it make in the world of upgrades? Is it worth upgrading at all? That depends on what you have. There are a few examples where swapping out to a newer chassis provides you with more performance.

Graphics cards from AMD and Nvidia come with a new form of technology known as GPU Boost. This is an auto-overclocking feature that increases or decreases the core clock speed, dependent on the card's temperature. Depending on the size of your case, and the amount airflow, you can affect the temperature of hardware inside. It's why blower fans and dual and triple dissipation card designs exist. Blowers can draw in vast quantities of air from a single vent hole, while the dissipation variety spreads the hot air around the chassis. If you're not providing enough cool air inside a chassis, you'll likely cripple your graphics card's overall performance.

On top of that, there's the ease of access of newer cases, with multiple 2.5-inch drives, better cable management, improved airflow, and support for a wider variety of cooling, motherboards, form factors, and more. So, upgrading your chassis can be very satisfying.

Low RPM fans with high airflow improve temps and reduce noise.

COOLING

Speaking of cooling, it's always a good idea to evaluate your situation. Ambient temperatures are always going to have a dramatic effect on overall internal temperatures. For instance, if you're stuck in Phoenix without aircon, your rig may very easily run at a full 10 degrees higher than, say, someone sitting in Chicago. With that being the case, you're going to need more efficient forms of cooling than a reference stock cooler to avoid thermals throttling your hardware. You can check a lot of this by running a few simple benchmarks, such as Prime95 and Unity's Heaven, alongside HW Monitor, to register just what temperatures your hardware is running at.

There are multiple ways you can help alleviate the throttling situation. Swapping out a reference CPU cooler for something more efficient, such as Cooler Master's Hyper 212 Evo, will help ensure your processor doesn't overheat far better than any stock cooler, and for $30, that's not a bad deal. We also suggest you run at least two intake fans in your chassis to provide sufficient airflow internally, to keep all your components well fed.

If you're thinking about overclocking to boost those performance figures some more, we would suggest you take a look at watercooling, especially when it comes to Intel's latest chips. You don't necessarily need something like a custom loop, but a single 120mm AIO liquid cooler, such as the NZXT Kraken X42 or Corsair Hydro H60i, will provide you with ample capacity to overclock any processor, outside of the extreme edition CPUs.

MEMORY

As DDR4 replaced DDR3 with the introduction of the X99 and Z170 chipsets, it failed to impress many hardware reviewers, purely because it added little to performance figures. Indeed, memory speeds seem inconsequential for the vast majority of users.

Improved capacities and lower power draw, though, mean we're seeing overall wattage requirements plummet. And if you want to upgrade your memory, we recommend you choose capacity over speed, and get the capacity you need: 8-16GB for gaming and everyday tasks; 16-64GB for video rendering and 3D modeling. Speed isn't a necessity.

VENGEANCE
CORSAIR
VENGEANCE
CORSAIR

DDR4 performance increases are negligible, but with increased capacity, it's a no-brainer.

If you're gaming, remember to match your screen to your GPU.

MONITORS

If you're not into gaming, upgrading your screen is a relatively painless affair. For professionals and graphic designers, the obvious route is to grab yourself one of those swanky IPS panels. Providing far better color reproduction, IPS and PLS are exceptionally useful for those looking for color accuracy from screen to printer. On top of that, there's the argument of resolution and screen real estate. Bumping up the size of your screen in conjunction with resolution, to maintain your pixel per inch ratio while also increasing screen real estate, makes it far easier to work on multiple programs at the same time. Going from a 24-inch 1080p screen to a 27-inch 1440p screen is a joy, and well worth the time of day.

That said, on the other side of the fence, for gaming it's a little more complex. Your screen choice is inherently symbiotically joined at the knee with your GPU. Choosing the right screen is dependent on what graphics card you have, what games you play, and what resolution you want to achieve. Working backward, if you're looking at gaming at 1080p, the RX 480 or GTX 1060 is a fine combination; at 1440p, the GTX 1070 or Fury X is a perfect solution; for 4K, you can almost get away with a GTX 1080 with some lower AA settings. For high refresh rates at 1440p, the GTX 1080 is the king.

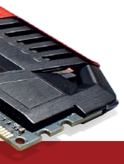
MOTHERBOARDS

Motherboards are by far one of the most underappreciated components in any given system. And it's not hard to understand why, either. Marketing gurus throughout the industry have been promoting these "performance-enhancing pillars of computing" for quite some time. If it's not Killer Networking touting a whole 200ns faster speeds than its Intel rivals, it's efficient capacitors, gaming technologies, and whatever else the whizz-kids want to slap on to each box to bump up the price tag.

That said, once you've waded through the mire of marketing sludge, and got to the grunt of what makes Intel's constant chipset updates more interesting than most, the whole concept is actually more intriguing than you would first think.

It's the enhanced connectivity that really sells it. Take a look at Z170, compared to last generation's Z97 chipset, and you'll see what we mean. Each generation sees improved support for a wide variety of connection standards. M.2 SSDs, which were so rare two years ago, are now commonplace, providing read and write speeds up to six times faster than any SATA SSD, and Intel accommodated for that.

Marketing spiel aside, higher priced motherboards generally tend to feature improved onboard audio, alongside more efficient VRMs, meaning you can operate higher overclocks and low undervolts on your system with ease.



Chipset is still king.

CHIPSET ADVANCEMENTS

	Intel Z97 Chipset	**Intel Z170 Chipset**
PCI Lanes	8x PCIe 2.0 @ 5Gb/s	**20x PCIe 3.0 @ 8Gb/s**
USB 3.0 Ports	6	**10**
USB 2.0 Ports	14	**14**
SATA Ports	6	**6**
DMI	2.0	**3.0**
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- 16GB Dual Channel DDR4-2400MHz Memory
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- 16GB Dual Channel DDR4-2400MHz Memory
- 256GB SanDisk X400 M.2 SSD + 1TB 7200RPM Hard Drive
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Operating system not found

—

BUILD THE ULTIMATE WINDOWS REPAIR DISC

Turn panic into minor irritation by crafting your own customized recovery disc *with Nick Peers*

One of the most stomach-churning moments in any PC user's life is when you switch on your computer to do some work or let off some steam, only to find Windows won't boot. You may get lucky—Windows 10 is smarter than previous versions, and can resolve certain issues on its own, but in many cases, you're left in an endless reboot loop. Assuming Windows even gets that far.

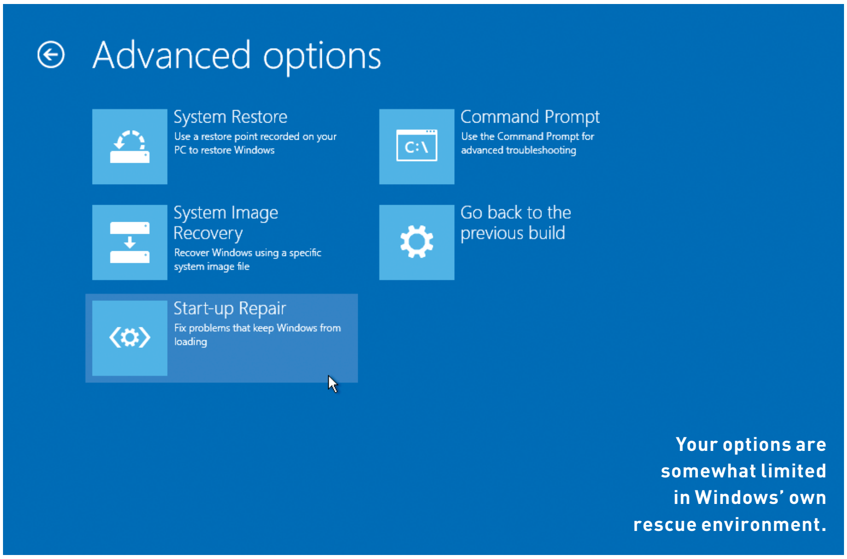
If Windows can't fix itself, what next? Do you have a recent backup of your data? What about Windows itself? Of course, it's perfectly possible to reinstall Windows from scratch, but that's the best part of a day lost to restoring your PC. And did we mention your data?

The solution lies in creating a bootable recovery disc—one that gives you the tools to repair most Windows woes, remove malware, and lets you pull data off the drive in case you're forced to bite the bullet and reinstall. In an ideal world, you'd be able to build a single rescue disc to cover all your needs. Linux users can smirk at this point, and bring out their Live CDs, giving them full-blown access to the OS they know and love. Wouldn't it be great if you could do the same in Windows?

The answer is: you can. In this feature, we'll show you how to create all the recovery media you'll ever need. The first disc will give you access to basic Windows recovery options, plus allow you to reinstall Windows if all else fails. The second offers more quick fixes to resolve common boot and loading problems, plus provides opportunities to recover files and back up or restore disk images. The final disc gives you the closest thing to a Linux Live CD: a fully functioning Windows-like environment to work in, with tools to help you troubleshoot problems, get online, and even add your own custom apps to beat malware and perform other tasks.

The time to create this media is right now, while your PC is still working, so turn the page, and protect yourself against disaster.

Advanced options
System Restore
Use a restore point recorded on your PC to restore Windows
Command Prompt
Use the Command Prompt for advanced troubleshooting
C:\
System Image Recovery
Recover Windows using a specific system image file
Startup Settings
Change Windows startup behavior
Automatic Repair
Fix problems that keep Windows from loading
msi


Advanced options
System Restore
Command Prompt
System Image Recovery
Go back to the previous build
Start-up Repair

System Restore: Use a restore point recorded on your PC to restore Windows

Command Prompt: Use the Command Prompt for advanced troubleshooting

System Image Recovery: Recover Windows using a specific system image file

Start-up Repair: Fix problems that keep Windows from loading

Your options are somewhat limited in Windows' own rescue environment.

Our first recovery disc is—as it's always been—the humble Windows installation disc. Can't boot into Windows? Boot from this instead, choosing the "Repair your computer" option when prompted. From here, you can attempt to fix startup problems automatically, launch System Restore to try rolling back to a previously working installation, or even restore Windows from a disk image. Advanced users can dig deeper, with access to the command prompt, too.

These days, most of us don't bother with DVDs, so it's unlikely that you've got any installation media to hand. Let's begin, then, by rectifying that situation. Start by typing "recovery" into the Cortana search box, then choose "Create a recovery drive." You're prompted to back up system files to it, which effectively creates a full-blown reinstall disc—you need an 8GB flash drive if you go down this route. Alternatively, uncheck the "Back up system files to the recovery drive" box, and make do with the basic repair options—in which case, all you need is a 512MB USB flash drive, although you won't be able to reinstall Windows if you go down this route.

(Note: If you want to create a bootable DVD, you need the Media Creation Tool—download the latest version from www.microsoft.com/software-download/windows10, and choose the ISO option when creating media for another PC, then right-click this file, and choose "Burn disc image" to burn your disc.)

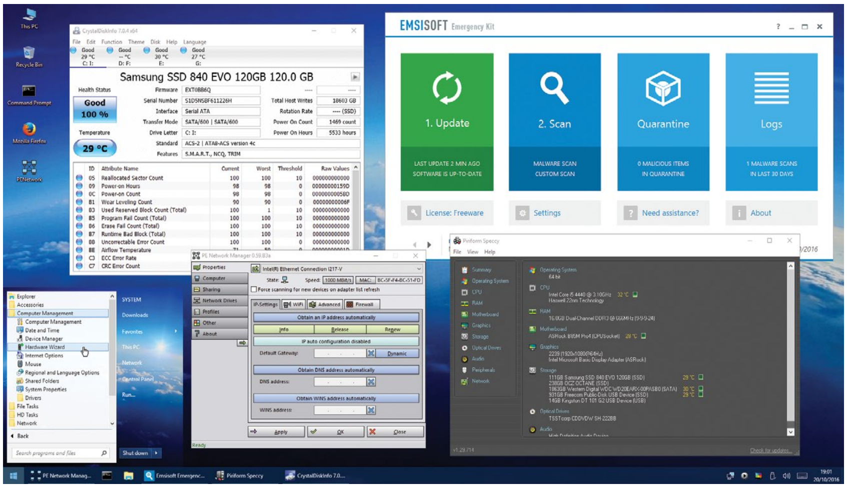
From here, if Windows fails to boot, pop in your installation disc or drive, and either make it your first bootable device in the BIOS, or look for an option to choose the boot device at startup, choosing the rescue media when prompted—note, if you're shown two options (typically "UEFI" and "USB"), choose "UEFI." From here, you can follow the prompts to hopefully bring your PC back to life, or—if all other avenues fail—reinstall Windows from scratch.

BEYOND THE BASICS

The Windows repair tool is all well and good, but there are times when it can't help. It can't disinfect your malware-infested drive, for example, and neither can you easily copy files from a badly mangled Windows installation, before formatting the drive, and starting again. If you want to protect yourself against either of these two possibilities, you need to augment it with something else.

Most antimalware vendors offer a recovery disc solution that specializes in rooting out malware—see the box opposite for details about creating a fourth recovery disc if you decide against the full-blown Live CD option later on in this feature. In the meantime, our second recovery disc takes things one step further than the Windows install disc. Lazesoft Recovery Suite Home Edition is free (for non-commercial use), so start by downloading and installing it from www.lazesoft.com/lazesoft-recovery-suite-free.html.

Lazesoft Recovery Suite contains four key components, all of which can be run directly from Windows (even in Safe mode). Of course, we're interested in building recovery boot media, so after launch, click the "Burn CD/USB Disk" link. You're asked to specify the target version of Windows—leave the default "DO NOT specify" setting applied for Windows 10 support, then click "Next." Choose your target media: CD/DVD, USB, or ISO file, then click "Start." Once created, check out the box over the page to find out what sort of problems Lazesoft can attempt to fix.

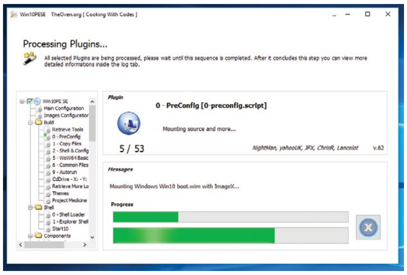

EMSISOFT Emergency Kit
1. Update
2. Scan
Quarantine
Logs
LAST UPDATE 2 MIN AGO
SOFTWARE IS UP-TO-DATE
MALWARE SCAN
CUSTOM SCAN
0 MALICIOUS ITEMS
IN QUARANTINE
1 MALWARE SCANS
IN LAST 30 DAYS
License: Freeware
Settings
Need assistance?
About
Samsung SSD 840 EVO 120GB 120.0 GB
Good
100 %
29 °C
PE Network Manager
Piriform Speccy
This PC
Recycle Bin
Command Prompt
Mozilla Firefox

Win10PESE provides you with a recovery environment based on Windows.

ONWARD AND UPWARD

Lazesoft Recovery Suite is well worth using in case it can fix your problem with just a few clicks, but what if it can't? In an ideal world, you'd be able to boot into a more complete Windows-like environment—one that employs the familiar point-and-click interface, while giving you access to a wider range of tools, full Internet access (being able to research error messages online could be a crucial step toward solving your problem), and more besides.

The good news is that all of this is possible—Microsoft produces a specialized


Win10PESE TheOven.org [Cooking With Codes]
Win10PE SE
Main Configuration
Images Configuration
Build
Retrieve Tools
0 - PreConfig
1 - Copy Files
2 - Shell & Config
5 - WoW64 Basic
6 - Common Files
9 - Autorun
CdDrive - X: - Y:
Retrieve More Lo
Themes
Project Medicine
Shell
0 - Shell Loader
1 - Explorer Shell
Start10
Components
Plugin
Messages
Progress

Processing Plugins...

All selected Plugins are being processed, please wait until this sequence is completed. After it concludes this step you can view more detailed informations inside the log tab.

0 - PreConfig [0-preconfig.script]

Mounting source and more...

5 / 53

NightMan, yahooUK, JFX, ChrisR, Lancelot v.62

Mounting Windows Win10 boot.wim with ImageX...

It can take a while to build your customized recovery disc.

version of Windows called Windows PE, with "PE" standing for "Pre-installation Environment." It's designed to be run directly from removable media, and has been adapted over the years by various individuals to provide recovery discs that can give you the best of all worlds—think Bart PE (based on Windows XP) and AOMEI PE Builder (Windows 7 or 8, but not 8.1 or 10).

One of the most successful PE-building tools is WinBuilder, and one user-friendly variant for Windows 10 comes in the form of Win10PESE. It's a flexible custom recovery tool builder that enables you to incorporate additional apps and tools if you need them, and can be burned to DVD or USB flash drive (1GB or larger).

BUILD YOUR OWN CUSTOM RECOVERY DISC

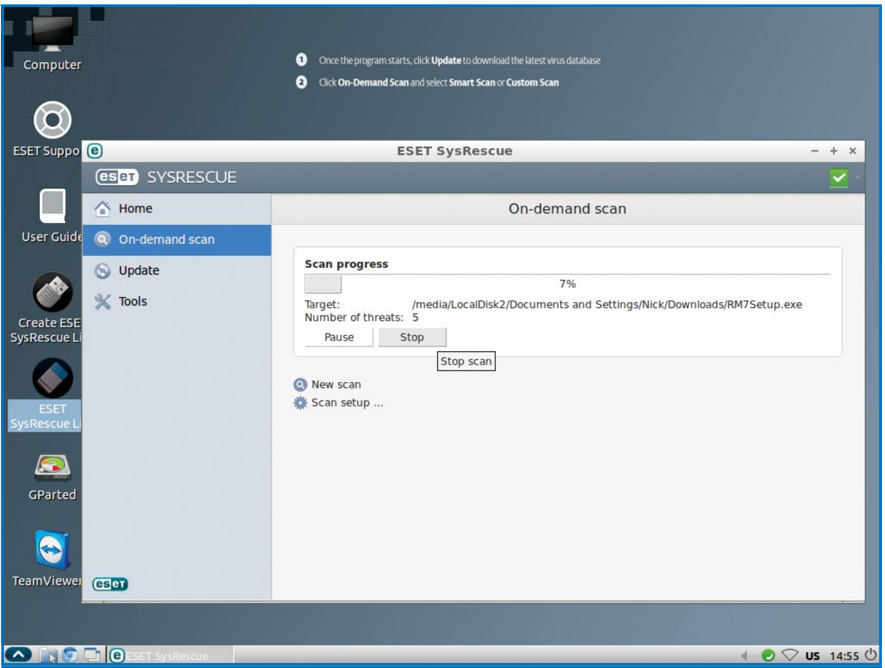
Start by visiting http://win10se.cwcodes.net/Compressed/, and click the link under the "Package" column to save the recovery builder tool in zip format to your hard drive. Once done, right-click the zip file, and choose "Extract All," then open the Win10PE_SE_<date> folder (the <date> corresponds to the latest build number), and double-click "BuilderSE.exe" to get started. The WinBuilder main screen reveals all the basic steps that you need to follow.

One of those steps involves giving the builder access to Windows 10 installation media—sadly, your recovery drive (or a disc created using the Media Creation Tool) doesn't count. Instead, click the "Microsoft Windows and Office ISO Download Tool" link in WinBuilder to access a tool that downloads the Windows 10 ISO. Once downloaded, launch the app, select "Windows 10," then choose the "Windows 10 Home/Pro" link from the drop-down menu, before clicking "Confirm." Choose your language, click "Confirm" again, then pick the 64-bit or 32-bit download, based on which version you currently have (press Windows-Pause/Break to find out if you're not sure), to download the ISO file.

Next, double-click the ISO file to allow Windows to mount it as a virtual CD/DVD drive (it'll be visible in File Explorer). Now return to Win10PESE, and click the "Source" button. Click the folder button under "Source Directory" to select the virtual disc drive.

In the program's left-hand pane, you'll see a number of collapsible folders that, when opened, revealed additional settings. If you're in a hurry, you can skip all of these to generate a basic, but usable, ISO file—just click the play button, sit back, and wait for the disc to be created. Once complete, look inside the Win10PE_SE_<date>\ISO folder for the ISO file you can subsequently burn to disc, by right-clicking the file and choosing "Burn disc image."

If you're creating a bootable USB recovery drive, however, you should take


Computer
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Create ESE SysRescue Li
ESET SysRescue Li
GParted
TeamViewer
ESET SysRescue
eset SYSRESCUE
Home
On-demand scan
Update
Tools
On-demand scan
Pause
Stop
Stop scan
New scan
Scan setup ...
eset
ESET SysRescue
US 14:55

① Once the program starts, click **Update** to download the latest virus database

② Click **On-Demand Scan** and select **Smart Scan** or **Custom Scan**

Scan progress

7%

Target: /media/LocalDisk2/Documents and Settings/Nick/Downloads/RM7Setup.exe

Number of threats: 5

MALWARE RECOVERY DISCS

One of malware's nastiest tricks is to cripple your PC so it's virtually impossible to clean. The malware typically suppresses known security tools from running, plus locks down your system in various ways, such as restricting which websites you can visit, barring access to Registry Editor, and even crippling Safe mode, inside which most antimalware tools can at least attempt to clean up the mess. To be fair, Windows 10 makes it hard enough to access Safe mode these days, so we're not sure why malware bothers, but we digress.

The solution here lies in visiting your security vendor's site to locate recovery media that includes a special version of your antimalware product that has network access to update itself, then focuses on detecting and cleaning malware. Depending on the tool and the infection, you should find any collateral damage has also been repaired, although tools such as Windows Repair (www.tweaking.com) and Complete Internet Repair (www.rizonesoft.com) can be used in Windows proper after the malware has been scrubbed if this doesn't prove to be the case.

These tools are completely free to use, so you don't need to be a paying purchaser of a particular package to use it. Just download the ISO file to the hard drive of a clean, working PC, then right-click it, and choose "Burn disc image" to burn a DVD from it, or use a tool such as Rufus (https://rufus.akeo.ie) to create a bootable USB flash drive from the ISO's contents, if the vendor in question doesn't provide a live CD/USB creation tool.

Major antimalware vendors offering bootable recovery discs include Kaspersky (https://support.kaspersky.co.uk/4162), Norton (https://security.symantec.com/nbrt/nbrt.aspx), ESET (www.eset.com/int/support/sysrescue), and AVG (www.avg.com/ww-en/download.prd-arl). Just Google your antimalware vendor and the words "recovery disc" or "rescue disc" to see if it's covered.

the time to expand the "WriteMedia" section. If your PC has a 64-bit UEFI (check with the manufacturer), select the "Copy to USB-Device" box; if not, select "Copy to USB-Device BCD Bootloader" instead, and check "Add Grub2-EFI (x64 UEFI only)" to ensure it boots. Click the folder button under "Please select the root directory of your USB-Device," to select the correct drive letter if necessary, then click "Copy to USB" to build your recovery drive from the ISO you just created.

TAKE IT FOR A TEST DRIVE

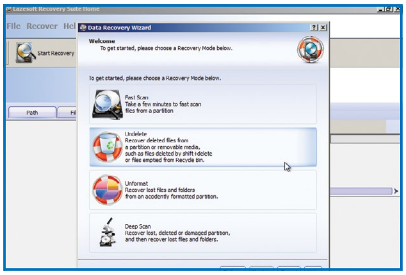
You can now test the recovery drive by booting from it in the same way you'd boot from the previous two recovery options. A menu appears—select "Win10PESE" to boot into your recovery environment. When the desktop environment pops up, you're prompted to choose your network connection type, if one is detected—the default DHCP is automatically selected after a five-second pause.

You then find yourself at a close approximation of the Windows 10 desktop, albeit one employing a more "classic" Windows look and feel. You'll see convenient shortcuts to File Explorer, the Command Prompt, and PENetwork on both the Taskbar and desktop—there's also a shortcut to Firefox, giving you access to the web. PENetwork merely launches the network manager, which should already be running and accessible from the Taskbar Notification area, alongside other controls, including one that enables you to set a different desktop resolution if you wish (note this feature doesn't work very well on UEFI systems—you're likely to find only the 1920x1080 and 1024x768 options work).

Click the "Start" button, and select "All Programs" to see what tools and utilities are included with the vanilla Win10PESE disc—shortcuts to critical Control Panel and system management applets are included, as are a handful of file-related tools (including 7-Zip), BootICE (for managing the boot manager), a PDF viewer, and some handy system tools, including Remote Regedit (for manipulating your Registry in case your boot problems stem from there), as well as access to the System Recovery options found in Windows itself.

These tools are all welcome and helpful, but you may be hankering after different tools and utilities—you may even simply want to be able to run a particular app, such as a word processor, while you try to fix your boot problem. The good news is that your Win10PESE environment can support third-party applications and programs, too.

We say "some" because, while certain program installers work, on the whole you're limited to portable apps, namely those that run directly from a folder. You can download these from the Internet (look under X:\Users\Default for the Downloads folder), but be sure to copy portable apps and key files to another drive if you want to keep them for another session—the "X" drive resides only in memory, which means it's wiped the moment you reboot.



Welcome
To get started, please choose a Recovery Mode below.

To get started, please choose a Recovery Mode below.

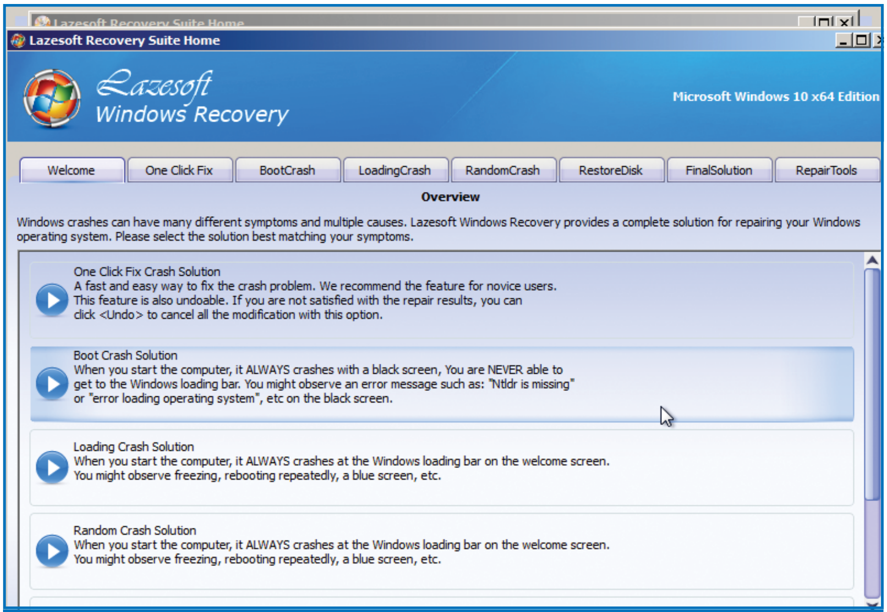
Fast Scan
Take a few minutes to fast scan files from a partition

Undelete
Recover deleted files from a partition or removable media, such as files deleted by shift+delete or files emptied from Recycle Bin.

Unformat
Recover lost files and folders from an accidently formatted partition.

Deep Scan
Recover lost, deleted or damaged partition, and then recover lost files and folders.

Lazesoft provides a wide range of data recovery tools.



Overview

Windows crashes can have many different symptoms and multiple causes. Lazesoft Windows Recovery provides a complete solution for repairing your Windows operating system. Please select the solution best matching your symptoms.

One Click Fix Crash Solution
A fast and easy way to fix the crash problem. We recommend the feature for novice users. This feature is also undoable. If you are not satisfied with the repair results, you can click <Undo> to cancel all the modification with this option.

Boot Crash Solution
When you start the computer, it ALWAYS crashes with a black screen, You are NEVER able to get to the Windows loading bar. You might observe an error message such as: "Ntldr is missing" or "error loading operating system", etc on the black screen.

Loading Crash Solution
When you start the computer, it ALWAYS crashes at the Windows loading bar on the welcome screen. You might observe freezing, rebooting repeatedly, a blue screen, etc.

Random Crash Solution
When you start the computer, it ALWAYS crashes at the Windows loading bar on the welcome screen. You might observe freezing, rebooting repeatedly, a blue screen, etc.

FIX WINDOWS BOOT PROBLEMS

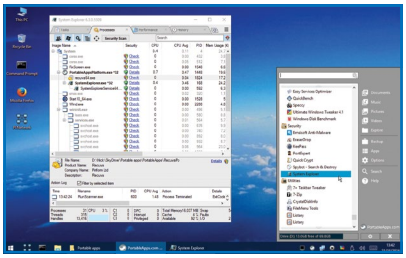
Lazesoft Recovery Suite offers a number of handy tools for fixing problems with Windows, plus it can help you recover data, too. Once created, reboot your PC from the Lazesoft rescue media. You'll eventually find yourself at the main Lazesoft Recovery Suite, with four recovery-based options: "Windows Recovery," "Data Recovery," "Disk Image & Clone," and "Password Recovery."

All four options are largely self-explanatory. Before running any recovery tools, we recommend taking a drive image of your current setup, which ensures you can always roll things back should the cure prove worse than the malady. Select "Disk Image & Clone," and choose "Drive to Image" to back up to a suitable external drive. Second, "Data Recovery" contains the full range of data recovery options, including simply pulling off regular files, as well as searching for lost and deleted files and partitions.

"Windows Recovery" attempts to fix your boot problems, offering a wide range of options across a series of tabs. There's also a one-click solution if you'd prefer the software to try to diagnose and repair on its own, with an "Undo" button that promises to reverse any changes made if the problem isn't fixed or gets worse.

If this fails, try the other options: "BootCrash," "LoadingCrash," and "RandomCrash." Each one steps you through a series of potential fixes to try, from repairing the MBR and restoring missing or corrupted files, such as Ntosknl.exe ("BootCrash"), to running memory diagnostics, and recovering the Registry ("RandomCrash").

The final tool—"Password Recovery"—promises to reset your Windows password if you've forgotten it, plus can reveal your Windows and Office product keys, should you need them. The former option only works with local passwords—in other words, if you sign in to Windows using your Microsoft Account, you need to visit https://account.live.com/password/reset to try to fix the problem.



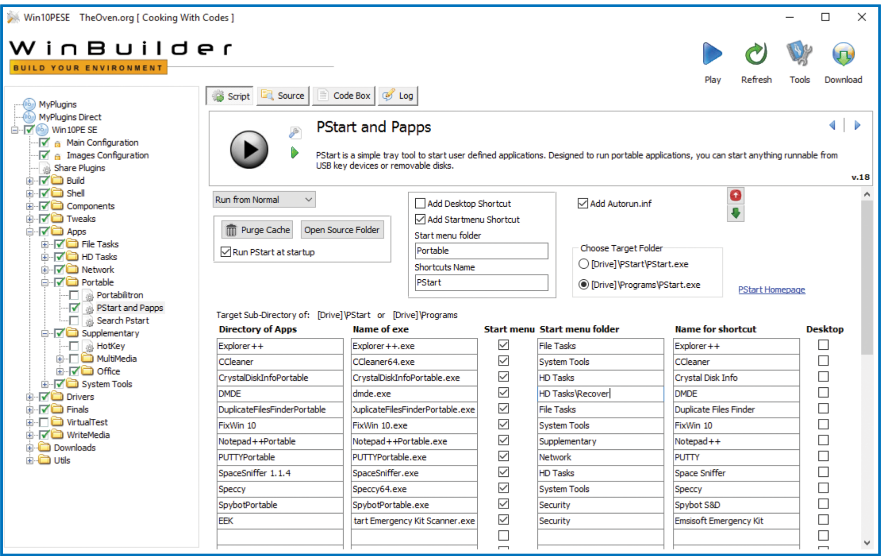
Win10PESE enables you to run portable apps from other drives.

BRING YOUR OWN

Luckily, you have a number of options should you wish to build up a more permanent collection of tools and utilities. Portable apps can be stored on another drive—a USB flash drive, say, or shared network folder. Access them via the Windows PE environment when needed.

A more elegant solution, and one that incorporates your applications directly into your recovery drive (with shortcuts through the Start menu), is to follow the "Add apps to your drive" box on the right. Also take the time to explore some of the other options that Win10PESE provides. Explore the various sections of the disk-creation tool; expand "Shell," for example, and you can change the packaged Start menu, plus configure its appearance. Expand "Components," and you can choose which Windows tools and accessories to include—add the .NET Framework to support a wider range of applications, for example.

If you have a virtual Windows machine to hand using a tool such as VirtualBox (www.virtualbox.org), use it to test your recovery disc—open "VirtualTest," and select "VirtualBox Emulation" to set up a dedicated virtual machine to test the ISO file with. It's a great way to check to see what effect your tweaks have, without having to recreate a USB flash drive or boot from your PC each time. But do remember to test the final disc or drive on your actual PC when you've got it working to your satisfaction, to make sure.



PStart and Papps

PStart is a simple tray tool to start user defined applications. Designed to run portable applications, you can start anything runnable from USB key devices or removable disks.

v.18

Run from Normal

☑ Run PStart at startup

☐ Add Desktop Shortcut
☑ Add Startmenu Shortcut
Start menu folder: Portable
Shortcuts Name: PStart

☑ Add Autorun.inf

Choose Target Folder
○ [Drive]\PStart\PStart.exe
● [Drive]\Programs\PStart.exe

Target Sub-Directory of: [Drive]\PStart or [Drive]\Programs

Directory of Apps	Name of exe	Start menu	Start menu folder	Name for shortcut	Desktop
Explorer++	Explorer++.exe	☑	File Tasks	Explorer++	☐
CCleaner	CCleaner64.exe	☑	System Tools	CCleaner	☐
CrystalDiskInfoPortable	CrystalDiskInfoPortable.exe	☑	HD Tasks	Crystal Disk Info	☐
DMDE	dmde.exe	☑	HD Tasks\Recover	DMDE	☐
DuplicateFilesFinderPortable	)uplicateFilesFinderPortable.exe	☑	File Tasks	Duplicate Files Finder	☐
FixWin 10	FixWin 10.exe	☑	System Tools	FixWin 10	☐
Notepad++Portable	Notepad++Portable.exe	☑	Supplementary	Notepad++	☐
PUTTYPortable	PUTTYPortable.exe	☑	Network	PUTTY	☐
SpaceSniffer 1.1.4	SpaceSniffer.exe	☑	HD Tasks	Space Sniffer	☐
Speccy	Speccy64.exe	☑	System Tools	Speccy	☐
SpybotPortable	SpybotPortable.exe	☑	Security	Spybot S&D	☐
EEK	tart Emergency Kit Scanner.exe	☑	Security	Emsisoft Emergency Kit	☐
		☐			☐

ADD APPS TO YOUR DRIVE

Why plug in another USB drive, or download tools from the net, when you can embed any portable tool directly into your recovery drive? Once embedded, the tools can be directly accessed through Win10PESE's Start menu, or via an icon in the Taskbar Notification area.

To add apps to your drive, first expand the "Apps → Portable" section in Win10PESE's left-hand pane, then check "PStart and Papps." Next, click the "Open Source Folder" button to open the folder where your portable apps need to be collected, each one inside its own folder. Once you've copied them into here, return to Win10PESE, and carefully enter the folder name of each app under "Directory of Apps," plus the name of the program's executable file under "Name of exe."

To add a shortcut to the Start menu, check "Start menu," and then specify the folder (get this from Projects\Win10PESE\Apps), and shortcut name; you can add a desktop shortcut, too, by checking the appropriate box. Finally, if you're burning a DVD, rather than creating a USB recovery drive, be sure to select "Run from RAM" to allow any antimalware tools to download and process updates. Then create the disc in the usual way.

What sort of portable apps should you be looking to add to your toolkit? Two recommended antimalware tools are Emsisoft Emergency Kit (www.emsisoft.com/en/software/eek), which utilizes two antimalware engines, and Malwarebytes Junkware Removal Tool (www.malwarebytes.com/junkwareremovaltool) for PUPs.

Piriform (www.piriform.com) provides portable versions of CCleaner (cleanup tool), Recuva (data recovery), and Speccy (system information). Another data recovery tool worth adding is DMDE Free (https://dmde.com), while a wide array of tools, from alternative browsers, to disk encryption, to drive health monitoring utilities, can be found at www.portableapps.com.

Finally, if there's a specific utility you want, check with the vendor's website—often, you can find portable builds buried away in the downloads section.

TROUBLE-SHOOT YOUR PC

Your recovery discs have been created, waiting for the time they'll be needed. Now your PC is refusing to boot, and you've whisked out your recovery discs. What to do? First, we recommend taking a drive image of the system partitions before you start attempting to fix things. Use Lazesoft for this task, unless you have an emergency boot disc coupled to your existing system imaging tool (such as Macrium Reflect Free), in which case use that.

With the drive image in place, you can start to attempt a fix for your problem. Begin with your Windows installation disc, to see if its Automatic Repair tool can get Windows up and running again. Make a careful note of any error messages if the problem persists, then move on to Lazesoft's Windows Recovery component (see the box on the previous page). If Lazesoft's fix-it tools fail to fix your loading problems, bring out the Win10PESE disc. Boot from this, then use the tools onboard—such as Remote Regedit—to try to fix known problems. Don't forget your Internet connection—use Firefox to browse for possible solutions to error messages, plus download additional software you might need, but didn't include on the disc. This is particularly handy if you're battling malware infections—you can track down specific removal tools, or locate your vendor's portable scanning toolkit, should our other suggestions fail to yield results.

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TECH PORN

Corsair Crystal 570X

THERE'S AN ART TO SYSTEM BUILDING. It starts with a thought, a concept, an idea. A conscious spark permeates the air as you home in on what, exactly, it is you want to construct. That first thought is often intrinsically connected to the next two decisions in any given system: What processor should you use, and which form factor? ATX, ITX? Micro? XL? Then, how many add-in cards will you be using? And among the myriad flexible, rotating questions, you arrive at one of the more important decisions: Which chassis?

Surprisingly, many people forsake this decision, because it adds little, if any, obvious performance. It is, however, the backbone of any good rig—as crucial as the motherboard, as artistic as in-game graphical frame rates, and as vital to cooling as any liquid-chilled all-in-one.

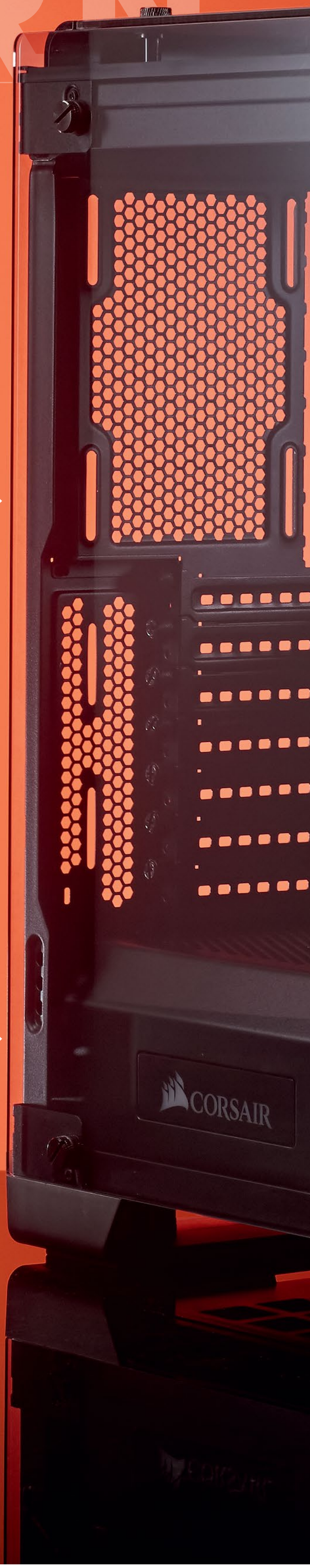
It's that art of design that Corsair has perfected here. The Crystal 570X is a masterpiece of folded metal and tempered glass, glinting in the sunshine as the componentry lies inside, primed and ready for the computational challenge of the day. This is the top of the top, the masterstroke of Corsair's Genius. It's a joy to build in, and a beauty to behold. **–ZAK STOREY**

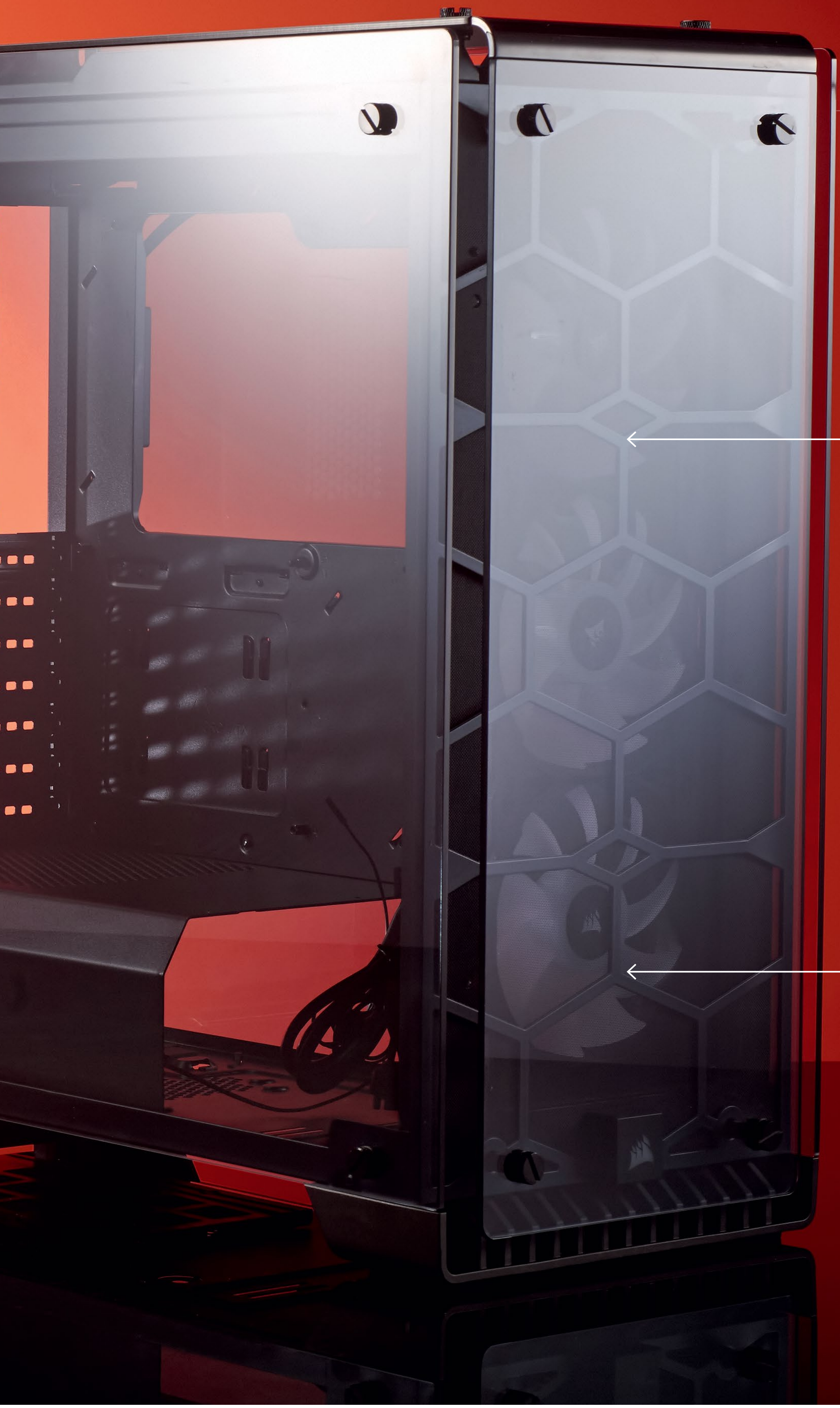
1 TEMPERED GLASS

It's impossible to miss the plethora of tempered glass panels because they're everywhere. The front, two side panels, and roof are comprised of the stuff, keeping everything on display. But beware smudgy fingerprints.

2 LED PSU COVER

Similar to NZXT's Manta, Corsair has integrated an LED lighting system into the PSU cover. The LED plate itself is also removable, so if you want to show off your power supply, you can.





3 FRONT RAD TRAY

The 570X not only supports up to a 360mm radiator in the front of the chassis, but the integrated radiator tray enables you to install the radiator outside the case, including fans, before sliding it back into position, for exceptional ease of use.

4 RGB LED FANS INCLUDED

Corsair has equipped this little beauty with three of its brand new, maglev-powered SP120 RGB fans. Connected via PWM and to a USB fan controller, not only will the SP120s keep your system cool, but they'll also dance the colors of the rainbow for you, too.

HDR AND THE PC: *IT'S COMPLICATED*

HDR monitors will be awesome. And awfully complicated, *says Jeremy Laird*

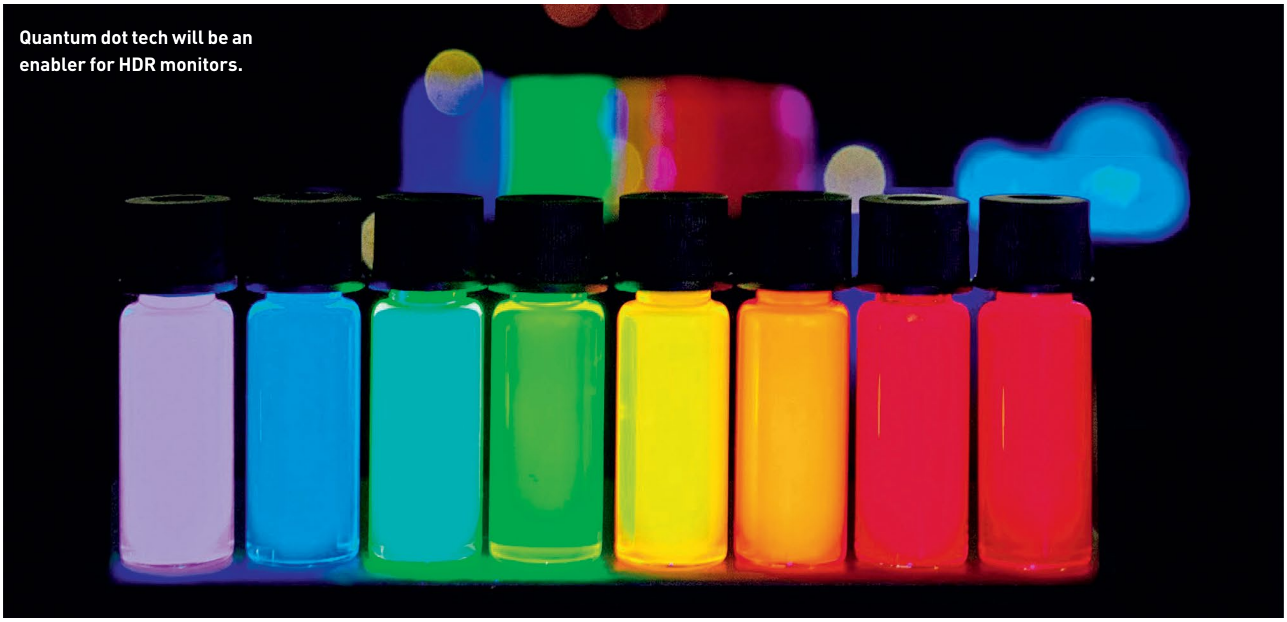
Forget curved panels, frame synching, 4K, and high refresh rates. There's a new technology that might just blow them all away for sheer visual pop. It's all about searing brightness and even deeper blacks. It's about dramatically increasing the numbers of colors a monitor can display. And it's coming soon to a PC near you. Get ready for HDR, people.

The basic concept of HDR (high dynamic range) is simple. It means stretching out the extremes of display capability—delivering more, even when that means less. But it's hard to point at any one feature and say, "This is HDR." Nor is it easy to define in terms of numbers. There is no one metric that definitively determines what an HDR display is. Instead, there's a number of standards that are competing to become the de facto definition of HDR.

This is going to cause confusion. Some monitor makers are likely to play a little fast and loose with how screens are marketed. Distinguishing between what you might call a full-HDR feature set and its constituent parts, such as wider color gamuts, is going to be a challenge both for marketeers and consumers. It's even tricky to define in terms of where it lies in the display chain. Game developers have talked about HDR rendering for years. But no games have output HDR visuals, and there were no displays to support that.

Nevertheless, HDR technology is rapidly becoming the norm in the HDTV market, and it's coming to the PC. So here's all you need to know.

Samsung's JS9500 is an HDR HDTV beast you can buy today.

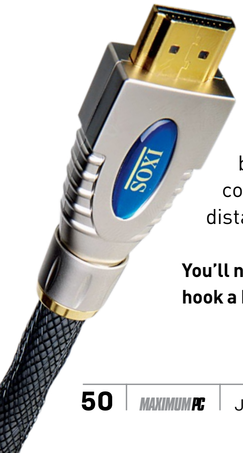

Quantum dot tech will be an enabler for HDR monitors.

What, exactly, constitutes an HDR display? Or should that be an HDR-10 display? Or maybe UHD Premium? Hang on, what about Rec. 2020? And BT.2100, SMPTE 2084, 12-bit color, and wide gamuts?

From the get go, HDR display technology presents a problem. It's difficult to define. Already, armies of competing standards are attempting to occupy HDR's high ground. Perhaps the best place to start, therefore, is to understand what HDR attempts to achieve. The aim is to simulate reality. Or, more specifically, to converge with the acuity or abilities of the human eye.

That's because the human eye has limitations beyond which it is futile to aspire. There are things in the real world that humans can't perceive, whether that's brightness, or colors, or granular detail. So, there's little point in trying to replicate them on a display. However, for the most part, what we can perceive still exceeds what displays are capable of. HDR, like several other technologies, aims to close that gap.

A handy example is Apple's Retina displays. Pack the pixels in a display close enough together, and the photo receptor cells in the retina—more specifically, the fovea, the most densely populated area of the retina—can no longer distinguish them individually. You've matched that aspect of the eye's capability. Adding more pixels will not improve image quality as perceived by humans. Of course, in this context, much depends on the distance between the eye and the screen. The further away the viewing point, the more densely packed the pixels appear. Apple isn't even consistent about what a Retina display is, and even the most detailed Retina display probably only has around one third the pixel density required to truly match the capability of the human eye. But the ambition to close the gap on the eye's capabilities is what matters, and it's what HDR is trying to do, too, only with different aspects of human vision.


You'll need HDMI 2.0a connectivity to hook a PC up to an HDR TV.

The aspects relevant to HDR are broadly captured by the notions of brightness and color. HDR display technology aims to offer a broader range of both. HDR isn't about adding ever more pixels. It's about making each pixel work harder and look punchier. Better pixels, not more.

For the most part, what we can perceive still exceeds what displays are capable of. HDR, like several other technologies, aims to close that gap.

The problem is that HDR isn't synonymous with a single metric. Color depth, contrast, and brightness are all in the mix. But no single aspect encompasses everything that makes for a brave new HDR display. Moreover, multiple HDR standards exist. Here's an excerpt from the definition of one of them, Rec. 2100, that gives a flavor of the complexity involved: "Rec. 2100 defines the high dynamic range (HDR) formats. The HDR formats are Hybrid Log-Gamma (HLG), which was standardized as ARIB STD-B67, and the Perceptual Quantizer (PQ), which was standardized as SMPTE ST 2084. HDR-10 uses PQ, a bit-depth of 10 bits, and the Rec. 2020 color space. UHD Phase A defines HLG10 as HLG, a bit-depth of 10-bits, and the Rec. 2020 color space, and defines PQ10 as PQ, a bit-depth of 10 bits, and the Rec. 2020 color space."

See what we mean? Anyway, let's dig into the meaning of HDR, starting with color. You may be familiar with the notion of color channels and, more specifically, the number of bits per channel—for instance, 6-bit or 8-bit. To cut a long story short, colors in a display are created by combining three primary channels in the form of subpixels—red, green, and blue, and hence RGB—to give a final target color. The bits per channel refer to the range of intensities available for each primary color channel. By varying the intensities, a range of colors is created, which is a mathematical function of the combined three channels.

BILLION COLOR QUESTION

By way of example, 8-bit-per-channel color, which until recently has represented the high end of consumer display technology, enables 16 million colors. Increase the color depth to 10 bits per channel, and the result is a billion colors. Take it up another notch to 12-bit, and we're talking 68 billion

HDR for $400

When it comes to inches-per-buck, TVs have usually looked cheap compared to dedicated PC monitors. But big-screen TVs haven't always made great monitors, mainly due to the relatively low resolution of TVs. Even a full 1080p HDTV is low res compared to many PC monitors.

Moreover, when you stretch that 1920x1080 pixel grid over a 40, 50, or 60-inch panel, the result is big, fat, ugly pixels. Yuck. With the advent of 4K resolutions, however, things changed. A 4K 40-inch TV makes for a similar pixel pitch as a 27-inch 2560x1440 resolution monitor. Ideal. But the first 4K TVs suffered from another historical TV shortcoming: low-fi display interfaces. Many couldn't accept a 4K signal with a refresh rate above 30Hz. Fine for movies, no good for a PC monitor.

However, with the wider adoption of HDMI 2.0, it was possible to drive a 4K HDTV at 60Hz from a PC video card. Suddenly, using a relatively cheap 4K HDTV as a PC monitor made sense. The same thinking applies to HDR TVs. Granted, there are limits to how big it's practical to go with a PC monitor. And the fat, ugly pixel problem reappears as sizes extend toward 50 inches and beyond. But 4K TVs with at least partial HDR support, such as the Samsung KU6300 series, can be had for little more than $400 for the 40-inch model. That's one hell of a deal.

However, such a screen won't have much, if anything, by way of PC-friendly features. Forget driving it beyond 60Hz. It almost definitely won't have adaptive sync technology, such as Nvidia's G-Sync or AMD's FreeSync. It may not offer the greatest pixel response. But perhaps the biggest killer, especially for gaming, is input lag. For HDTVs, a bit of input lag isn't a major concern. On the PC, it's downright horrible. The moral of this particular story, then, is that it's absolutely essential to try before you buy.

colors. That's a lot. So how does that map to the capabilities of the human eye?

The target here, or at least one target, is something known as Pointer's Gamut. It's a set of colors that includes every hue that can be reflected off a real-world surface, and seen by the human eye. How it is calculated probably doesn't matter. Nor does the fact that there's a fair bit of variance from one human to the next. What is notable is that it's only reflected colors—not luminescent colors, which can't be fully reflected off material surfaces. Hence, even if a display completely captures Pointer's Gamut, it doesn't cover everything the eye can see.

However, Pointer's Gamut is far larger than the standard color spaces or gamuts of PC monitors. By way of example, the full UHD Premium specification (which is one of several HDR specs) includes a color space known as Rec. 2020. It very nearly covers 100 percent of Pointer's Gamut. The most common color space PC monitors support is sRGB, which only covers a bit more than two thirds of the colors of Pointer's Gamut.

But supporting sRGB isn't the same as fully achieving sRGB. In other words, your current sRGB screen probably can't achieve the full range of sRGB colors, which is a space that's significantly smaller than Pointer's Gamut, which in turn doesn't encompass every color the human eye can perceive. Put simply, your screen may look nice, but odds are that it's pretty crappy at creating colors by any objective metric.

To grasp that difference in numbers, simply recall those bits-per-channel. UHD Premium requires a minimum of 10 bits per channel, or a billion colors. Unless you have a high-end pro display with 10-bit color, an HDR screen means a massive jump from around 16 million to at least a billion colors.

The other major part of the HDR equation is, effectively, contrast. It's a bit more complicated than that because true HDR capability goes beyond mere contrast. To understand why, consider a display that can fully switch off any given pixel. In other words, a display capable of rendering true black tones. Strictly speaking, this is virtually, though not absolutely, impossible for an LCD monitor—there is always some leakage of light through the liquid crystals. It's theoretically possible to have an individual and active backlight for each, but that's highly impractical. Instead, technologies where pixels create their own light are a far more efficient route to infinite contrast. Which is where OLED displays come in. But we digress, and you can read about OLED displays in the boxout over the page.

The point is that if you have true or nearly true blacks, almost any amount of light constitutes effectively infinite contrast by comparison. So even a really dim screen

Lenovo's Yoga X1 is one of the first PCs to boast OLED screen tech.

A Question of Standards

Probably the biggest challenge for anyone interested in HDR is knowing what to buy. At best, HDR is an umbrella term that covers a range of technologies and features. However, some standards are emerging that should make buying easier.

Currently, the two best established standards are HDR-10 and Dolby Vision. The most obvious difference between the two is color depth. As its name suggests, HDR-10 requires 10-bit per channel color capability, while Dolby Vision ups the ante to 12-bit. How much difference that will make in practice remains to be seen, but on paper, Dolby Vision is superior in that regard.

The other major difference is support for brightness. HDR-10 supports up to 1,000cd/m^2 of brightness for LCD displays, while Dolby Vision goes up to 4,000cd/m^2, with plans to support 10,000cd/m^2 in the future. Again, Dolby Vision is superior, and it is likewise much more expensive.

What's not clear is whether PC monitor manufacturers will adopt either of these standards. Making matters even more complicated is the fact that a monitor may have some HDR capabilities without being marketed as an HDR display. That's especially true of any OLED PC display. OLED panels have very high contrast capabilities. Indeed, an OLED display is only required to generate around half the brightness of an LCD display to comply with the HDR-10 standard for that very reason.

Complicating things even further, the UHD Premium standard adopts HDR-10 as a subsection of its requirements. So it's another label you may see attached to a display, even if it's not a separate HDR standard in a strict sense. Ultimately, it's early days for HDR displays, and it's not clear which standard (or standards) will become the norm on the PC.

Could HDR, rather than VR, be the next big thing in PC gaming?

would be capable of infinite contrast if the pixels were fully switchable, as per OLED. Thus HDR doesn't just deal with relative values of brightness, but also absolutes. Again, by way of example, UHD Premium stipulates a maximum brightness of at least 1,000cd/m^2 for an LCD screen—roughly three times brighter than a typical LCD.

BACKLIGHT OR BLACK

As for how that's achieved with existing LCD tech, obviously a more powerful backlight is needed. But, very likely, a backlight composed of subpixels (though not as many as the LCD panel), and thus capable of local dimming, is required. A single, big, dumb backlight cranking out massive brightness would enable greater brightness, but it would also guarantee that the black levels are very poor in some scenarios.

For an idea of what this combination of huge contrast and extreme brightness will enable, imagine the powerful flash of light as a car passes on a really bright day, and the glass momentarily reflects the sun directly into your eyes. Even an HDR screen won't put out real-world levels of light for such events. But the effect of simulating them on screen will be far, far more realistic.

Displays that capture much or all of these new color, contrast, and brightness capabilities already exist. HDR is the latest big thing in HDTVs, and using an HDR HDTV as a monitor is an option for PC enthusiasts. HDR is also a new feature in the latest refresh of games consoles from Microsoft and Sony. But that same technology is coming to screens designed to be used with PCs. The downside is that it will likely come in many confusing forms. Already, there are inconsistencies with terminology, such as "4K" and "UHD," which are used virtually interchangeably but are not the same.

Then there's the likelihood that some monitors will support certain aspects of what's known as HDR, but not others. For instance, you could argue that, for PC gaming, what matters is the contrast and brightness aspects of HDR, along with speed, in terms of pixel response. So you might not want a more expensive and slower LCD panel that's required to deliver

Even Asus's latest 34-inch RoG might look pedestrian when the first HDR monitors arrive.

Gaming in HDR

If there's anything that proves what a nightmare technology HDR is to wrap one's gray matter around, it's surely gaming. After all, PC game developers and graphics hardware vendors have been talking about how great HDR gaming is for years.

But if the first HDR displays are only just emerging now, how could PC games have been HDR for years? The answer to that is actually fairly simple. Some games have been rendering to HDR targets for some time. It's just the output from the game engine is compressed or tone-mapped down from HDR to SDR format before being sent to the display. So the HDR claims weren't a lie in strict terms, but it's questionable just how much benefit internal HDR rendering was when the output and the display technology was all SDR.

Whatever, with the arrival of bona fide HDR display technology, the PC games industry is boning up to support full HDR visuals. In fact, it's partly being driven by the adoption of HDR technology in the latest round of games console refreshes from Microsoft and Sony.

What's more, converting an existing SDR PC game to HDR is not a particularly onerous task. Straightforward mapping processes can expand SDR color maps to HDR ranges via algorithmic translation without massive effort. So, there's a good chance that patches adding HDR support to existing games could become widespread in the near future. Nvidia is reportedly working on an HDR patch for *Rise of the Tomb Raider,* for instance. But it will probably be games with console siblings, such as the *Forza, Battlefield,* and *Gears of War* series, that will be the first games to get full HDR capability on the PC. It's also worth remembering that just about anything, be it games or HD video, will look better on a proper HDR display, even if the content itself isn't mapped for HDR output.

the wider color gamuts. You might want what amounts to an HDR backlight with local dimming, combined with a TN panel with relatively limited colors. But would that be an HDR monitor? Or something else? Tricky. Other displays may take up the broader color gamut, and leave off the local dimming. It's very early days, and it will probably take a few years to shake out, especially when you factor in the likely coming transition from LCD tech to OLED.

Speaking of that transition, it's yet to be seen how PC monitor manufacturers will achieve HDR capabilities. If LCD tech is used, a backlight with local dimming is required to achieve the extreme contrast ratios. Quantum dot tech can also be used to bolster the range of colors on offer in combination with a 10-bit or 12-bit LCD panel. But arguably, any attempt to achieve HDR visuals via LCD tech is a bit of a kludge.

Instead, OLED displays with pixels that are their own light source are a much more efficient way to do things. What's more, OLED technology lends itself better, in cost terms, to more compact PC displays than massive HDTVs. It's a similar rationale that has seen OLED become common in smartphones. Very likely, therefore, HDR LCD monitors will be at best a stopgap before OLED becomes the dominant solution. With that in mind, it might make sense to consider a cheap HDR LCD TV as your own stopgap solution, while we wait for OLED HDR monitors to become affordable.

CAN YOU HAVE IT ALL?

Things get even more complicated with the technologies needed to achieve UHD color depths beyond the screen itself. With all those colors and ranges of intensity, HDR is seriously bandwidth hungry. HDMI 2.0, for instance, can't do the full 12-bit per channel at 60fps and 4K resolution—for that you need HDMI 2.0a. Upping the refresh rate to 120Hz and beyond only makes the bandwidth limitation worse. In other words, a display that does it all—120Hz-plus, adaptive-sync, HDR, the lot—isn't coming any time soon. Even when it does, your existing video card almost certainly won't cope when gaming.

You'll also require a compliant video card to enable HDR visuals. For Nvidia GPUs, that's Maxwell or Pascal families (GTX 960, GTX 980, GTX 1070, GTX 1080, and so on). For AMD, its Radeon R9 300 Series can do HDR at 60Hz up to 2560x1600. For full 4K 60Hz HDR output, only the latest Polaris boards, such as the RX 480, can pull it off.

Then there's the question of content. In terms of video, there's very little out there. It was only in 2014 that the Blu-ray standard was updated to support 10-bit per channel color. HDR photos are in more plentiful supply. Even most smartphones support HDR image capture, achieved by capturing the same image multiple times with a range of exposures, then combining the results into a single image. In theory, HDR video capture works the same way, it's just harder to achieve because of the need to process so much data in real time. As for games, much of the early HDR content on the PC will likely be driven by the parallel emergence of HDR tech on games consoles (see boxout above).

HDR is one hell of a complicated technology: Currently, it's not clear when the first dedicated HDR monitors will go on sale, which standards they will conform to, or how much they will cost. But HDR is coming. So we'd better get ready.

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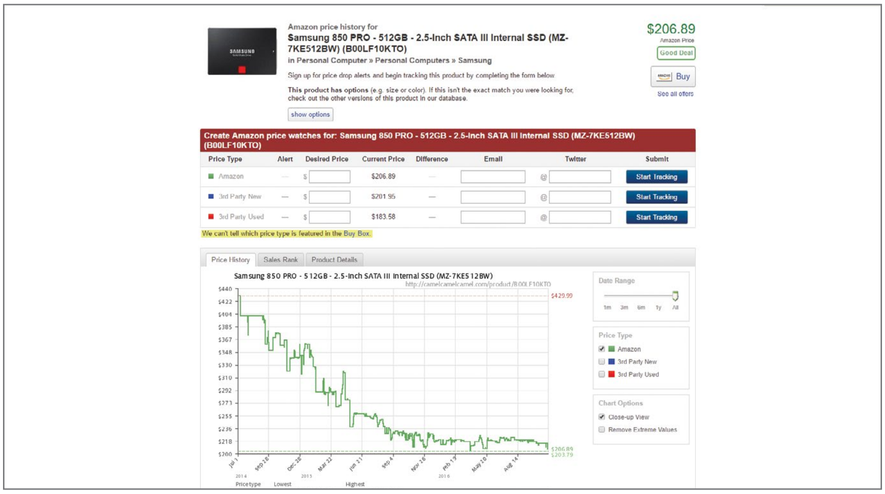
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

WINDOWS TIP OF THE MONTH



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🟥 3rd Party Used	—	$	$183.58	—		@	Start Tracking

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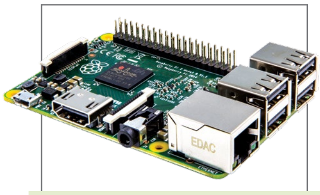
Jul 1
Sep 28
Dec 28
Mar 22
Jun 21
Sep 4
Nov 26
Feb 13
May 20
Aug 14
2014
2015
2016
Pricetype
Lowest
Highest
Date Range
1m
3m
6m
1y
All
Price Type
☑ Amazon
☐ 3rd Party New
☐ 3rd Party Used
Chart Options
☑ Close-up View
☐ Remove Extreme Values

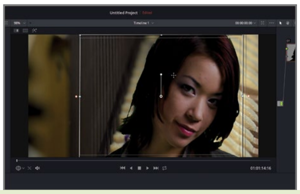
AMAZON “BARGAINS”

We love bargains. And the best place to look nowadays seems to be Amazon. However, a deal might not be quite what it seems, with resellers artificially bumping prices up just so they can reduce them the next day. A good way to check is the nifty website at http://camelcamelcamel.com. Copy and paste the product URL into the top bar, and it gives you a breakdown of how the price has fluctuated over the last few months.

MAKE – USE – CREATE



58
Make some noise with Sonic Pi



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Edit video with professional tools

68
Build a Linux budget-busting box

ZAK STOREY
REVIEWS EDITOR

WATER DAMAGE

This week, a work colleague of mine approached me with a slight conundrum. He'd managed to spill a half-drunk can of Coke into a system fan at top of his build, which proceeded to distribute the sugary liquid throughout the entire rig. With him convinced that his power supply had failed, I offered to dissect the build to see just what exactly had died.

After swapping out the PSU and noting that the system still refused to power on, I checked the old power supply. Disconnecting all the power connectors on the motherboard and GPU, and making sure the switch at the back was set to off, I then bridged the 24-pin with a small paperclip, and turned it on again (a trick taken from liquid cooling, to prime a loop). The system fans and hard drives whirred into life, indicating the PSU was fine.

I then pulled the GTX 970 out of the dead system, and plopped it on to our test bed—sure enough, the test bed refused to boot, indicating that the GPU was causing a short circuit—judging by the smell emanating from the card, it wasn't particularly surprising. After doing the same with the Intel Core i5-4690K and DDR3, it was a simple case of plugging everything back in except the GPU, and watching the system light up and power on as normal. Conclusion? Our Events Manager is a bit clumsy, and is now $300 poorer as he needs to fork out for a 3GB GTX 1060 to replace the aging Gigabyte card.

↘ submit your How To project idea to: comments@maximumpc.com

IFIXIT presents:

AUTOPSY

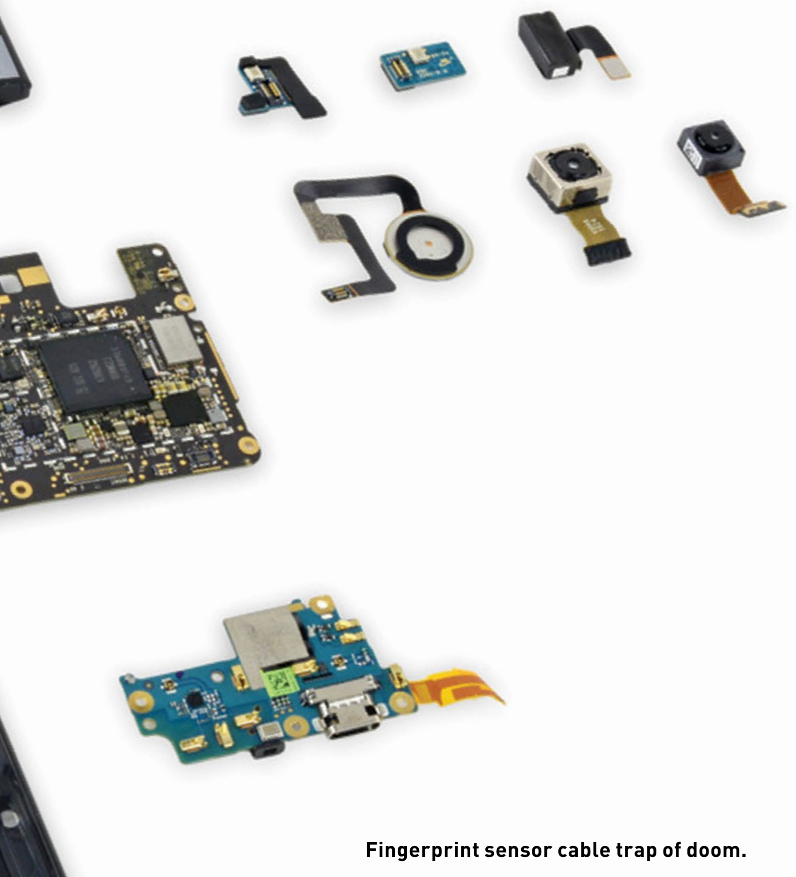
THIS MONTH WE DISSECT...

About iFixit

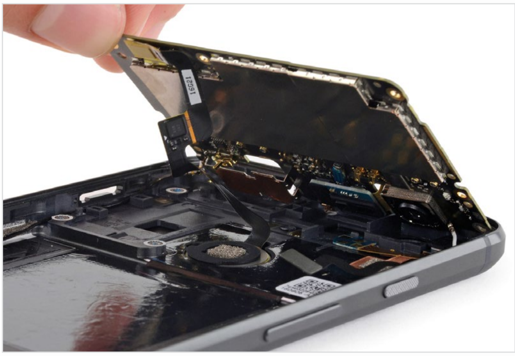
iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Google Pixel XL

Relatively simple—eerily similar to Apple.



Fingerprint sensor cable trap of doom.



BACKGROUND

Today marks our first ever teardown of a phone designed entirely by Google: the Pixel XL. What to expect? At first glance, it bears more than a passing resemblance to an iPhone—but it's the innards in which we're interested...

MAJOR TECH SPECS

- 5.5-inch AMOLED display, with QHD 1440x2560 resolution (534 ppi), and 2.5D Gorilla Glass 4
- Quad-core, 64-bit Qualcomm Snapdragon 821 processor (2.15GHz + 1.6GHz), with 4GB LPDDR4 RAM
- 12.3-megapixel, f/2.0 main camera, with phase detection autofocus, and laser detection autofocus; 8MP selfie camera
- 32GB or 128GB built-in storage
- Pixel Imprint back-mounted fingerprint sensor
- USB Type-C port and 3.5mm headphone port
- Android 7.1 Nougat

KEY FINDINGS

- Given the familiarity of this iPhone lookalike, our confidence nears cockiness as we take a play from our iPhone 7 Plus guides, heat an iOpener, and select our lucky opening pick. After a minute of heat and a minute of prying, we lift open the phone from the top, expecting to expose its inner workings. But a screwed-down bracket on the display cable halts our progress. Time to dust off our driver, and dive a little deeper.
- The slim and rigid midframe is likely made of magnesium, and is clipped on to the body of the phone. When we say "rigid," we expect it to not be "bendy." We expected wrong. Oops! On the left, the midframe holds a mysterious ribbon connector and an earpiece speaker. And to the right, the rest of the phone, complete with motherboard in mat black.
- Two strips of strong adhesive secure this HTC-made battery, but the pull tab does its job without heat. This 13.28Wh battery beats the 11.1Wh iPhone 7 Plus, but not the Galaxy S7 Edge, with its 13.86Wh powerhouse. Worthy of note: The Galaxy Note 7 packed a 13.48Wh battery before its demise.
- We really wanted to look at this motherboard, but were thwarted by a fingerprint sensor cable boobie trap! Fortunately, it's easy to disarm. Next is another mini board with mic, and the rangefinder that enables laser autofocus.
- Repairability Score: 6 out of 10 (10 is easiest to repair). Many components are modular, and can easily be replaced once the display assembly is removed. The battery has a removal tab, and is adhered by a modest amount of adhesive, making removal painless. All the screws are T5 Torx. The opening procedure requires prying up a thin, poorly-supported display assembly, making it difficult to open the phone without damage. In addition to screws, the midframe is secured by snug, press-fit notches, which make its removal (and subsequent repairs) laborious.

Make Some Noise with Sonic Pi

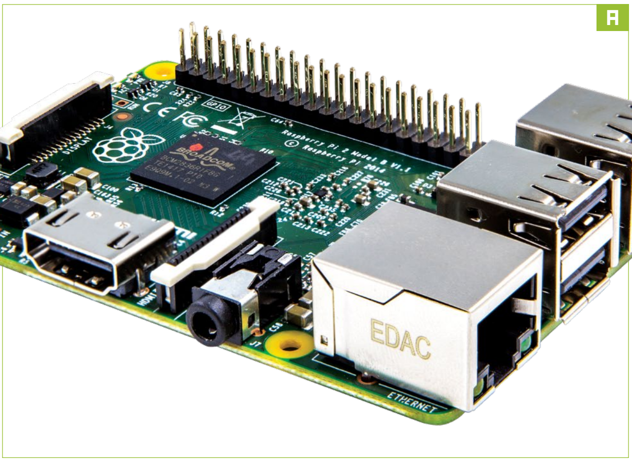
YOU'LL NEED THIS

RASPBERRY PI
Any model.

RASPBIAN
Available from www.raspberrypi.org/downloads.

THIS MONTH, we're serving up a selection of "phat beats" using nothing more than a Raspberry Pi [Image A] and Raspbian (which comes with Sonic Pi preinstalled). This is the personal project of Dr Sam Aaron, and the goal of Sonic Pi is to introduce creativity into programming via music, and reduce the friction that's encountered by children learning to code – for example, the alignment and indentation of code, and syntax errors.

Sonic Pi uses the Ruby programming language created in the mid 1990s by Yukihiro "Matz" Matsumoto, which was an easy-to-learn and syntax-friendly alternative to the languages of that time. Sonic Pi refines the Ruby language to provide a number of easy-to-use functions that enable learning. In this tutorial, we're teaching the basics of Sonic Pi, then consolidating that knowledge with a piece of music. –LES POUNDER



1 INTRODUCING SONIC PI

Sonic Pi comes preinstalled with Raspbian, but if you have an older installation, it's possible that your version of Sonic Pi is quite old. It's well worth updating the software installed on your Pi by opening a terminal, and typing the following:

```
$ sudo apt-get update
$ sudo apt-get upgrade
```

» If you are prompted to confirm installation, please do so. With Sonic Pi installed, you can find the application in the "Programming" menu. Open the interface, and you'll see that it is split into three vertically tiled panes. The top pane [Image B] contains a row of buttons that are used to control the playback of your composition, save the composition to a file, and also record the audio to a WAV file. Further buttons are used to reduce the text size of your code, align and indent code automatically, and access the Help/Preferences system. The center pane [Image C] contains the area in which code is written, which is split into a series of workspaces, enabling you to write multiple compositions or test logic in a spare workspace [Image D]. To the right of the code space is the Preferences area [Image E], where configuration changes can be made at the bottom. We also have the Help area [Image F], which contains extensive help documentation and example compositions.

2 YOUR FIRST NOTES

Let's start our musical adventure by playing a note. In the coding pane, type `play 60`. Now click "Run" on the top pane. You should hear the note play briefly. What does 60 mean? Well, it refers to the MIDI (Musical Instrument Digital Interface) numbering scheme, which is used in professional music production to cover the protocol by which data is sent to and from computers and digital instruments, but it also covers the connection made between the devices. The "60" note refers to a "c4" note, but we can just use the name of the note instead, so you could type `play :c4`.

» If we wanted to play a series of notes, we could type out something like:

```
play :c4
sleep 1
play :g4
sleep 1
play :d4
sleep 1
```

This is a correct but rather long-winded approach. Instead, Sonic Pi enables you to play patterns of notes in the same manner with:

```
play_pattern [ :c4, :g4, :d4 ]
```

» Perhaps the notes are a little too slow for you? Well, Sonic Pi has you covered. To speed up the playback of a composition, we can set the beats per minute (BPM) for playing that pattern of notes faster:

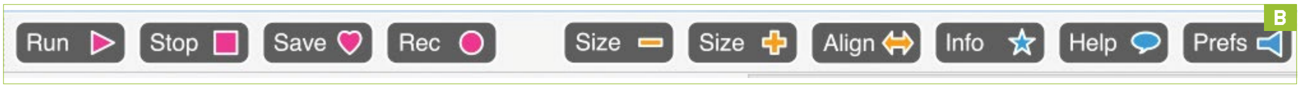
```
use_bpm 240
play_pattern [ :c4, :g4, :d4 ]
```

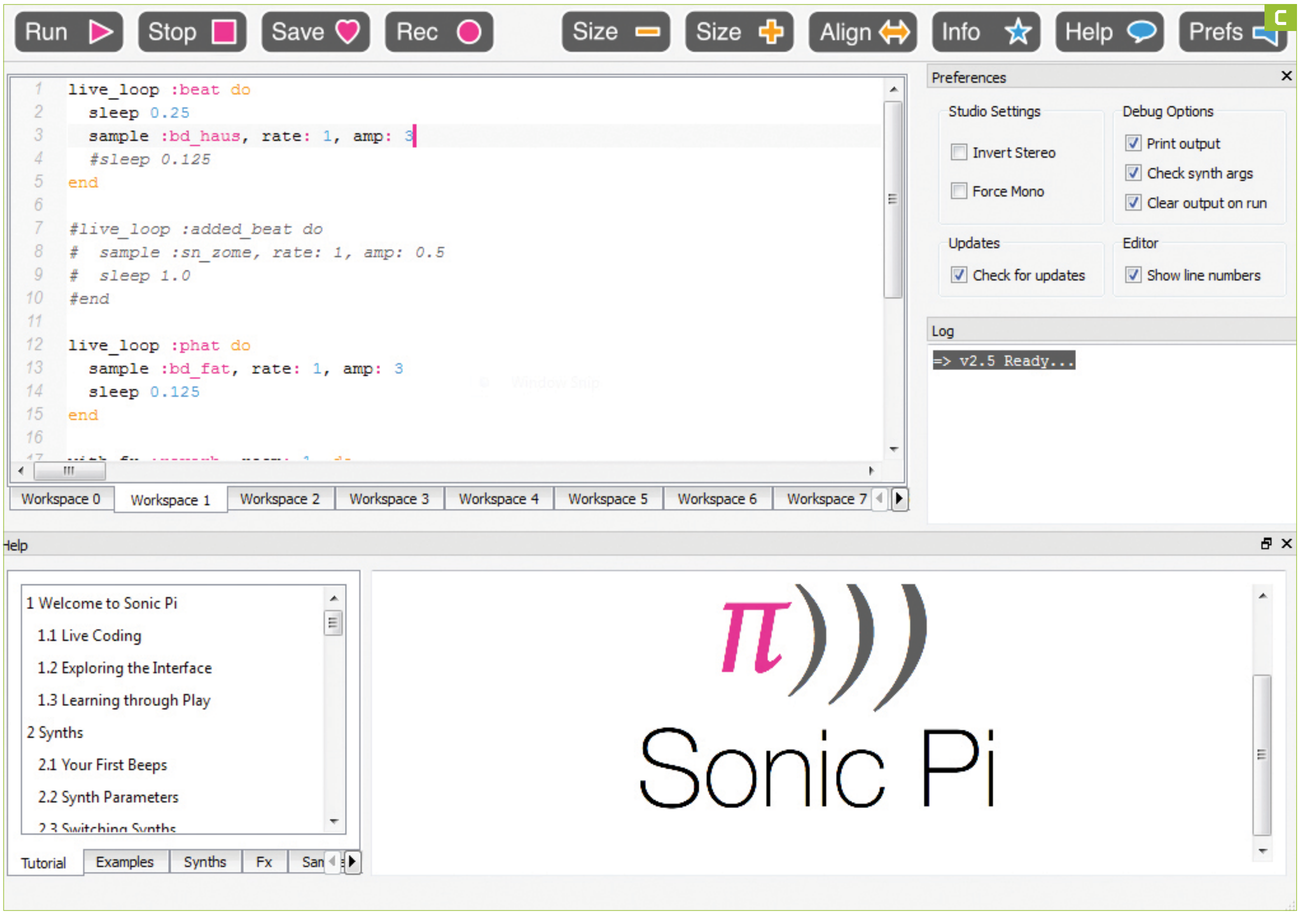
3 USING SYNTHS

OK, we can play a series of notes, but right now, it's not very exciting, so let's introduce another feature of Sonic Pi: synths.

» Synths enable a note to be played with many different instruments, similar to electronic keyboards and other digital instruments. So let's alter our code to use a synth:

```
use_synth :dsaw
play :c4
```




Run
Stop
Save
Rec
Size
Size
Align
Info
Help
Prefs
Workspace 0
Workspace 1
Workspace 2
Workspace 3
Workspace 4
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Workspace 6
Workspace 7
Help
1 Welcome to Sonic Pi
1.1 Live Coding
1.2 Exploring the Interface
1.3 Learning through Play
2 Synths
2.1 Your First Beeps
2.2 Synth Parameters
2.3 Switching Synths
Tutorial
Examples
Synths
Fx
San
Sonic Pi

```
live_loop :beat do
  sleep 0.25
  sample :bd_haus, rate: 1, amp: 3
  #sleep 0.125
end

#live_loop :added_beat do
#  sample :sn_zome, rate: 1, amp: 0.5
#  sleep 1.0
#end

live_loop :phat do
  sample :bd_fat, rate: 1, amp: 3
  sleep 0.125
end
```

Preferences

Studio Settings
☐ Invert Stereo
☐ Force Mono

Debug Options
☑ Print output
☑ Check synth args
☑ Clear output on run

Updates
☑ Check for updates

Editor
☑ Show line numbers

Log

```
=> v2.5 Ready...
```

›› Click "Run" to hear the difference. Now that we can play a note with a synth, let's put it into a loop to repeat playback. Sonic Pi can create an infinite loop using the `loop do...end` construct. Any code inside the loop repeats forever. To ensure that your code is properly indented, click the "Align" button in the top pane to automatically align the code:

```
loop do
  use_synth :dsaw
  play :c4
  sleep 1
end
```

›› Click "Run" and you hear the c4 note played once per second until "Stop" is clicked. But what if we want to iterate a loop for a set number of times? Ruby has an easy way to do this:

```
2.times do
  use_synth :dsaw
  play :c4
  sleep 1
end
```

4

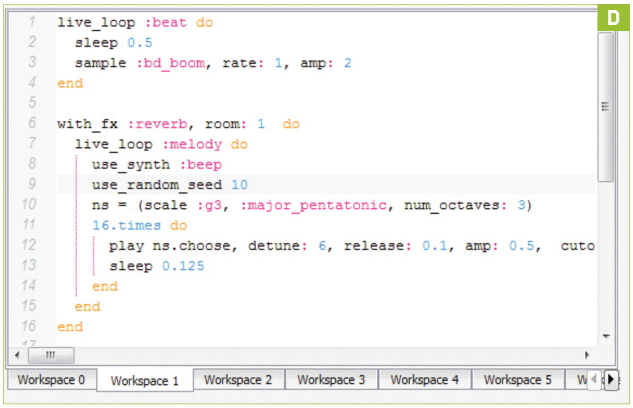
PLAYING LIVE

Another kind of loop is a live_loop. This is an infinite loop to be used when live coding a performance. Changes made to code inside a live_loop don't instantly take effect—rather, they require the user to click "Run" to instigate the changes the next time the loop is run. Live_loops enable the user to create concurrency where multiple segments of code are working together to form the backdrop of our music. The syntax for a live_loop is similar to a standard loop, but requires a name to be given

LIVE CODING!

Dr Sam Aaron is a bright and bubbly individual, who knows his craft well and loves to show others, so it's no surprise that he's a big advocate of live coding, the practice of coding in front of a live audience. Sam was part of the band Meta-ex (http://meta-ex.com), along with Jonathan Graham. Together they merged coding with musical instruments to create unique performances, where the audience could see the code transform to match the tone and pace of the music.

At a recent OpenTech event, we saw open data, in the form of natural disaster data, being used to shape the notes used in a rather eclectic piece of music. The piece, co-produced by Leah Borromeo and Jamie Perera, used data sonification. However, this wasn't a real-time project, which opens the door for Sonic Pi to be used with open data in a live coding exhibition. Data from a number of sources, such as newspapers, weather forecasts, and governments can be "mashed" into a live coding musical composition that can illustrate the subject of the data being used.



```
live_loop :beat do
  sleep 0.5
  sample :bd_boom, rate: 1, amp: 2
end

with_fx :reverb, room: 1  do
  live_loop :melody do
    use_synth :beep
    use_random_seed 10
    ns = (scale :g3, :major_pentatonic, num_octaves: 3)
    16.times do
      play ns.choose, detune: 6, release: 0.1, amp: 0.5,  cuto
      sleep 0.125
    end
  end
end
```

to the loop. So, let's create a loop named "beat," which incorporates the `play_pattern` function that we learned earlier. Then click "Run" to play.

```
live_loop :beat do
  use_synth :dsaw
  play_pattern [ :c4, :g4, :d4 ]
  sleep 1
end
```

» Change the c4 note for an f4 note, and click "Run"—you should hear the note change in pitch accordingly. We can also play a pattern backward, using Ruby's handy `.reverse` function, like so:

```
live_loop :beat do
  use_synth :dsaw
  play_pattern [ :c4, :g4, :d4 ].reverse
  sleep 1
end
```

5 RANDOMIZE THINGS

As well as playing notes forward and backward, we can also play random notes using two functions:

```
play rrand(50, 100)
play rrand_i(50, 100)
```

» The first `rrand` can play any note between 50 and 100, including any floating point MIDI values, but the second `rrand_i` can only play integer-based MIDI values between 50 and 100.

» A common practice in programming is to create a function in which we can contain a block of code, then when we wish to use this code, we merely call the function by its name:

```
define :loopy do
 use_bpm 480
 use_synth :dsaw
 play_pattern [ :c3, :c4, :c5, :c6 ]
 sleep 0.5
end
live_loop :testy do
 loopy
end
```

» In our example, we create a function called "loopy," and use the `do...end` construct to store the code that will set the BPM to 480 beats per minute, and play a pattern using `dsaw synth`, before sleeping for half a second. Inside a live_loop, we call the function "loopy" by its name, and the code contained inside is run.

6 USING SAMPLES

The last Sonic Pi concept we're introducing is samples. These are segments of audio that are pre-recorded, and in the music industry, they are used often to embellish a song using clips from classic songs. To use a sample in a new live_loop, we need to recreate the following code below the existing `live_loop :beat`:

```
live_loop :samples do
  sample :loop_amen
  sleep sample_duration :loop_amen
end
```

» The sleep statement for this loop is unusual, because it doesn't have an integer or float value visible. Rather, we instruct Sonic Pi to learn the duration of the sample used, and use that as the sleep value.

7 BUILDING OUR TUNE

Now that we have the basics under our belt, let's start building our composition. Click on a blank workspace, and start your piece by creating a live_loop called "beat." This will contain the code that forms the beat of our piece. Let's put a sample inside the live_loop. When completed, click "Run" to hear the beat.

```
live_loop :beat do
  sample :bd_haus
  sleep 0.5
end
```

» So, our beat is a sample played two times per second, which is a BPM of 120—quite quick and punchy. Let's build upon the beat by creating another live_loop, which will contain a melody. Before we start the live_loop, we add some FX to our audio. To do this, we use the "reverb" FX plugin to add a spacious feel to the notes. We pass the "room 1" argument to instruct Sonic Pi to use the maximum-sized room available—in other words, this gives the sound the maximum available spacious sound. This melody uses the "beep" synth for any notes played.

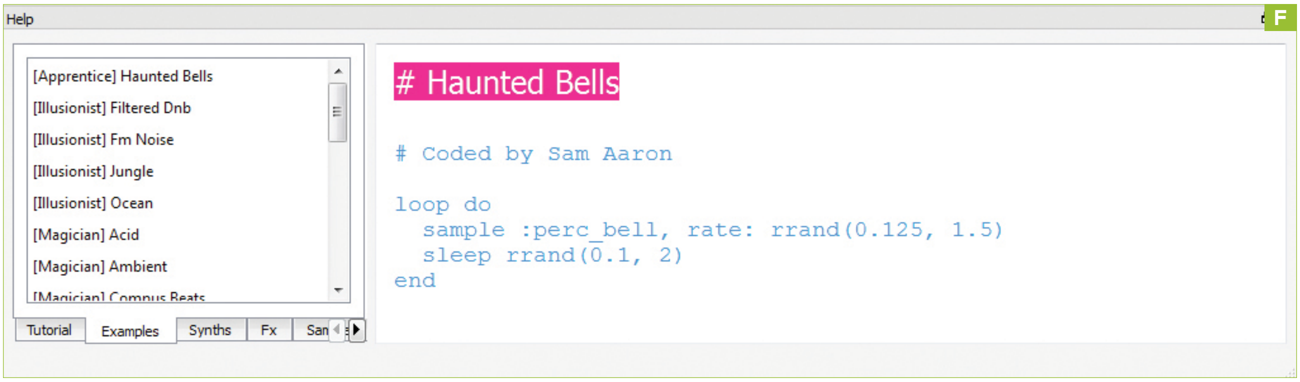
MINECRAFT IN THE MIX!

Minecraft on the Raspberry Pi has become the killer application to teach Python to classes, and Sonic Pi has attained the same status for its use of music. But what if there were a way to merge the musicality of Sonic Pi with the fun of building new worlds in *Minecraft*? Well, now there is, and from version 2.5 of Sonic Pi, you can also integrate *Minecraft* into your musical compositions. At the time of writing, this is still a bleeding-edge feature, but there's already a great deal of functionality available, such as getting the position of the player or a block, changing the position of the player and block type, and posting data to the chat window. The syntax is exceptionally easy to pick up, and integrates seamlessly into the standard Sonic Pi syntax structure, enabling *Minecraft* functionality to be added to any previously written Sonic Pi compositions.

To use Sonic Pi with *Minecraft*, simply open the *Minecraft* application, load a world, open Sonic Pi 2.5, and choose a *Minecraft* function to trigger the connection, such as the chat window:

```
mc_chat_post("Hello World")
```

Run the code and—hey presto!—you're connected.



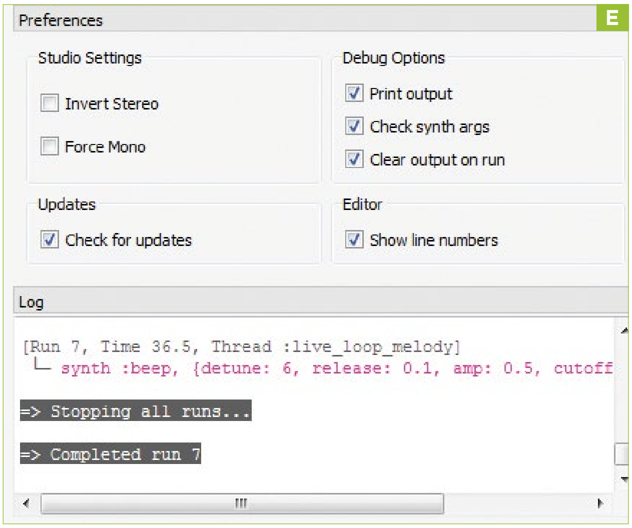
```
# Haunted Bells

# Coded by Sam Aaron

loop do
  sample :perc_bell, rate: rrand(0.125, 1.5)
  sleep rrand(0.1, 2)
end
```

8

USING FX PLUGINS

We then add a seed to the mix, which changes the starting point for any random numbers generated by Sonic Pi. Numbers generated using "random" are never truly random, merely chaotic in nature. We used 66678 as our starting point, but try other numbers to see how the composition changes. Next, we create a variable called "sound," and in there we store a scale of notes in the key of g3. Next, we instruct Sonic Pi to perform the next bank of code 16 times, so it chooses the notes from the "sound" variable, then uses a number of arguments to achieve the following: Detunes the notes to create a slightly off sound to each note; alters the fade out and release of the note, so that it fades quickly; and amp controls the level of the note played—in this case, it's half the volume relative to the others. Then, we modify the cutoff to use a random note between 70 and 80 to cut off certain frequencies. We now instruct the code to wait for 0.125 seconds. Lastly, because we have opened three loops using `do`, we must close them correctly:

```
with_fx :reverb, room: 1  do
 live_loop :melody do
  use_synth :beep
  use_random_seed 66678
  sound = (scale :g3, :major_pentatonic, num_octaves: 3)
  16.times do
   play sound.choose, detune: 6, release: 0.1, amp: 0.5, cutoff:
rrand(70, 80)
   sleep 0.125
  end
 end
end
```



☐ Invert Stereo
☐ Force Mono
☑ Print output
☑ Check synth args
☑ Clear output on run
☑ Check for updates
☑ Show line numbers

```
[Run 7, Time 36.5, Thread :live_loop_melody]
 └ synth :beep, {detune: 6, release: 0.1, amp: 0.5, cutoff

=> Stopping all runs...

=> Completed run 7
```

» Click "Run" to play the composition. Remember that you can alter the random seed to produce a different sound. You can also alter the scale of notes, by changing g3 to another scale—g5, c4, and so on. You can also alter `major_pentatonic` to `minor_pentatonic`, to produce a much darker and more sorrowful tone.

9

THE FINALE

Our next live_loop is used to create an ambience to the composition, and again, we're using an FX plugin. This time, it's "ixi_techno," a low-pass filter between the minimum and maximum cutoffs. We call the loop "ambience," and first off, it performs a block of code eight times. Using the "hollow" synth, we play the note c3 with an amplitude of 0.5, putting the note into the mid-tone mix of our composition. We then wait for one second before entering into another loop that iterates eight times. This time, however, it plays the "ambi_choir," a haunting choir sound, at standard speed, but mixed down into the composition, so that it appears as background noise. We then sleep for one second, before closing the four loops that have been created:

```
with_fx :ixi_techno do
 live_loop :ambience do
  8.times do
   use_synth :hollow
   play :c3, amp: 0.5
   sleep 1
   8.times do
    sample :ambi_choir, rate: 1, amp: 0.2
    sleep 1
   end
  end
 end
end
```

» Click "Run" to hear your composition play. Does it need any tweaking to match your goal? You could try changing the sample playback rate from 1 to 0.5, or to 2 for different results.

10

LET THE MUSIC PLAY!

So, using Sonic Pi and some simple coding, we have managed to create a looping piece of audio that can be recorded using the "Record" button, and uploaded to SoundCloud, or used in your YouTube videos.

» There are plenty of Sonic Pi examples on the official website, just point your browser at http://sonic-pi.net and click the "Examples" link. It's also worth checking out the video of Sonic Pi's creator, Sam Aaron, performing live at TEDx Newcastle—you'll find it on the main page.

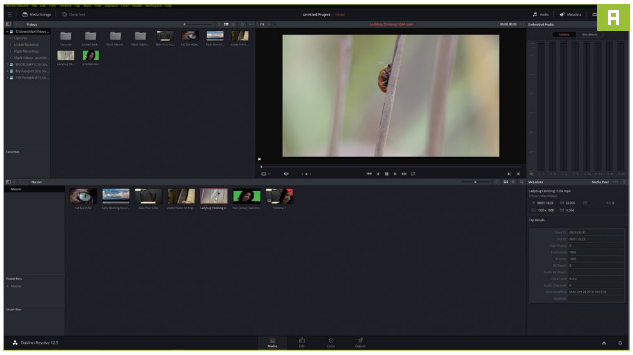
Edit Video with Professional Tools

YOU'LL NEED THIS

BLACKMAGIC DAVINCI RESOLVE 12.5
Download it for free from www.blackmagicdesign.com.

SOURCE VIDEOS
Use your own, or grab some from Archive.org for testing.

Video editing for free is the dream, isn't it? Nobody really wants to invest in professional software just to stitch together a family video or a bit of gaming footage. But there's a reason we call it a dream: Frankly, the majority of free video-editing software is terrible. Windows Movie Maker does a passable job, if you're not looking for particularly presentable results; ShotCut, recently making its way over from Linux, has the instability and baffling UI typical of its original home. There's a stack of other packages out there that can apparently do the trick, but they're so obtuse and buggy that we wouldn't touch them. Which means it's time for some DaVinci Resolve. Recently made free (as an ad for its full version), Blackmagic's editor is actually used, for real, for Hollywood film grading, and it includes full editing facilities to boot. –**ALEX COX**



1

PREPARATIONS

Begin by downloading and installing DaVinci Resolve. It's a reasonably big package at over 400MB, and there are a few dependencies you may need, although the installer takes care of these for you. Although you need to register in order to download it in the first place, there are no nasty hidden extras to watch out for in the installer, as far as we can tell. Launch the software and take the tour to see a preview of a few of Resolve's key features, then let it check your computer to see how well it'll perform. You can now create a new project. Bear in mind that the maximum resolution of the free version is 1080p, because 4K editing is locked to the paid-for real deal. The next choice is for the editor's keyboard shortcuts, which you can set to match those of a number of other high-end editors—we're using DaVinci's default set throughout this guide, but you may already be familiar with Premiere, Final Cut, or Avid Media Composer.

2

LOOK AROUND

Resolve's interface is split into four parts, which you can access using the bar at the bottom of the window, or by selecting them in the "Workspace → Primary Workspace" menu. The first one you'll see is the media workspace [**Image A**], so let's take a quick and very basic tour. Starting at the top-left, there's a list of folder locations, which you use to locate your media; once a folder is located, a list of clips appears to its right, which can be previewed in the window to the right of that. You add your clips to your project by dragging them to the large pane at the bottom of the interface, or view information about the currently selected clip in the bottom-right pane. Drag a few clips into the bottom pane, and hit Shift-4 to head to Edit mode.

3

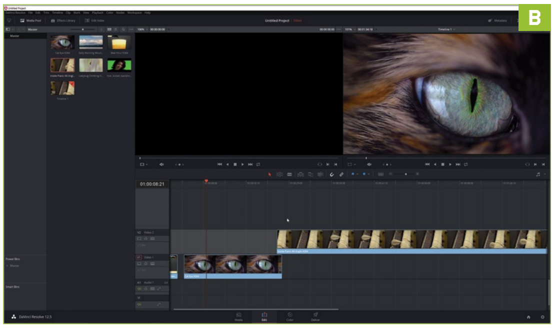
THE EDITING ROOM

Now we're into the meat of Resolve's editing facilities [**Image B**], which will be familiar to anyone who's used a non-linear editor before. You get access to the clips you've selected, a timeline at the bottom of the screen, a couple of preview windows at the top, and a limited list of effects and transitions. Begin by dragging one of your clips on to the timeline—we're using freely available public domain footage sourced from Archive.org, so if you're looking to try Resolve, but don't yet have any footage to use, that's a solid legal source. When you drop your clip in, two tracks are created: one for the video, and one for its associated audio track. Each of these elements can be edited independently, although they begin (usefully) linked together, so your audio won't end up out of sync.

4

TRIM AND SPLICE

Hover your mouse over the ends of your clip—scroll, or use your mouse wheel to zoom out, if you can't see all of it—and you can top and tail it by left-clicking and dragging. While this is a viable tactic, it's far from the most useful way to trim a clip, mainly because you have to keep previewing it to see exactly where you've trimmed to. Better, then, to splice, putting a break in your clip at the exact point it needs to be cut. Use the controls of the rightmost preview window to view your clip, and stop it at the exact point you'd like it cut. Alternatively, drag the red position marker to your splice location. Then select the razor blade tool along the top edge of the timeline pane, and click on the position marker to break the clip into two. Since this is non-linear editing, there's no need to worry



SYSTEM REQUIREMENTS

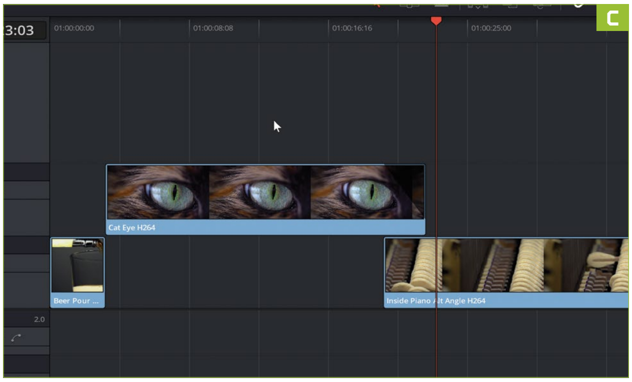
Resolve is not for the faint-hearted, and not for the faint-of-PC. It absolutely requires OpenCL support to operate, so forget about it if you're looking to edit on a machine that doesn't have a modern discrete graphics card. You'll probably need to click through a couple of error messages when you load it, mainly due to Resolve looking for specialist editing hardware you probably don't have—don't worry about these, it'll work just fine without. You may also find that it doesn't play nicely with your monitor; we had some issues getting it to run on a 4K panel, and it needed a little convincing about our Windows scaling options.

If you want to take Resolve further, you could consider an upgrade: The full version weighs in at an eye-watering $995, and if you're really serious about using it, you can pick up the software with a dedicated control surface (shown above)—featuring a host of buttons, jog wheels, and integrated LCD panels for fingertip control—at a positively eye-loosening $29,995. This really is one for the professionals.

about this brutality: you won't affect your original files at all. Go ahead and clean up by selecting the arrow tool, clicking the excess, and hitting Delete.

5 LAYERING UP

Let's add a second clip now, and look at Resolve's hierarchy. Drag your next clip and drop it above the original one, which creates a new video track. Overlap it with your first clip, and preview your video; you'll see that the original has basically disappeared, since this new clip is at the top of the pile. This order matters, because it means you're able to reliably mix video tracks together using transitions and cross fades. So, let's do that. Move your upper clip close to the end of the lower one, overlapping just slightly. Hover, using the arrow tool, over the top-left edge of your top clip [**Image C**] to reveal a white handle; drag it to the right, and drop it in line with the end of the first clip and—hey presto!—you've created a cross fade.



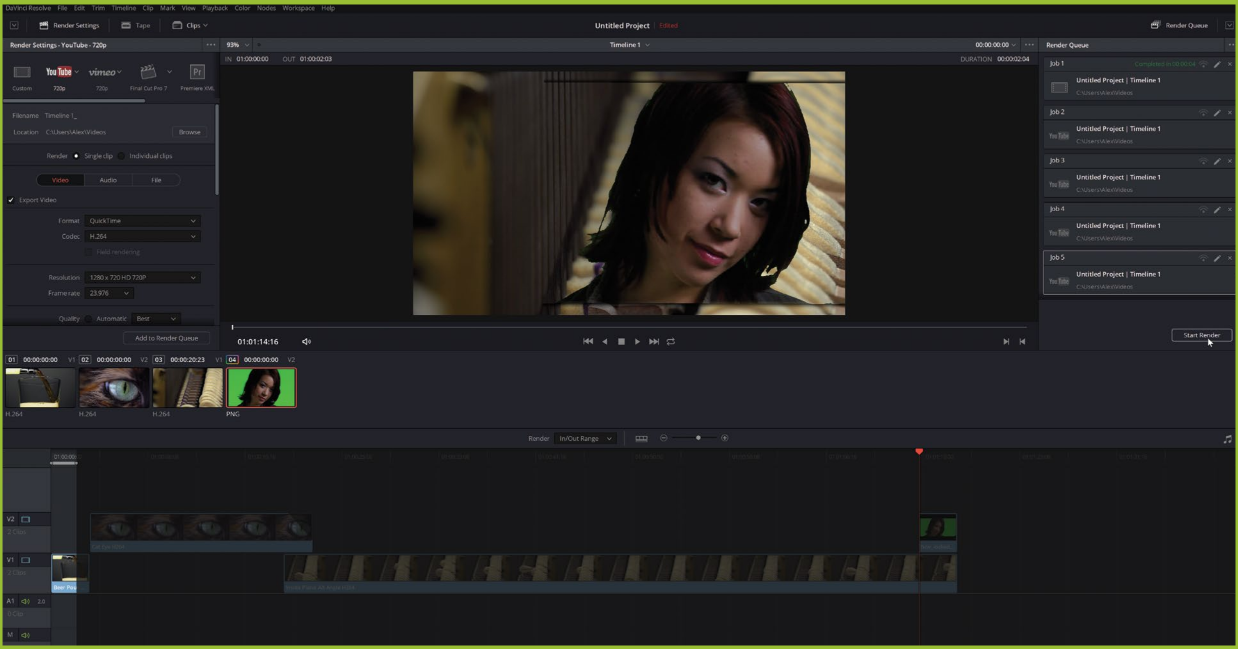
6 MAKING THE GRADE

You could spend all your time in Resolve's editing interface, and not worry about the rest of it. But Resolve was built as a color grading tool and, frankly, its non-linear editing portion is not quite as tasty as that of some of its competitors. The real meat, then, lies in the "Color" section, which hosts the grading, compositing, and effects tools. You're working with a lesser collection than in the full version, but this is still a broadcast-standard selection. The only problem? The node-based system that Resolve uses can be a bit of a dog to get your head around. So, before we even touch the controls, let's explain it with a little analogy. Many editors allow you to add effects to video using layers; think of this as a nice cream cake. If you've missed something out, it's going to be a very messy job to pull it apart, put in the additional ingredient, and assemble the whole thing back into some presentable order. Using nodes is more like working with cupcakes; each one can be revised and decorated exactly as you wish; filling up your cupcake stand doesn't mean they're locked in place—if one looks a bit shoddy, you can pull it out without ruining the rest—and you're free to eat them in any order you like. It's an incredibly flexible way to add effects, and efficient, too: once you've created a node, you can reuse it as you wish.

7 COMPOSITION

So, let's try out this section with a bit of green screen—otherwise known as chroma key—compositing. We're using the clip "Hair Detail" from www.hollywoodcamerawork.com/greenscreenplates.html as our test, since it gives us a good chance to fiddle with some relevant settings. If you're creating your own green

RENDER TIME



Render Settings - YouTube - 720p

Filename: Timeline 1_

Location: C:\Users\Alex\Videos

Render: ● Single clip ○ Individual clips

☑ Export Video

Format: QuickTime

Codec: H.264

Resolution: 1280 x 720 HD 720P

Frame rate: 23.976

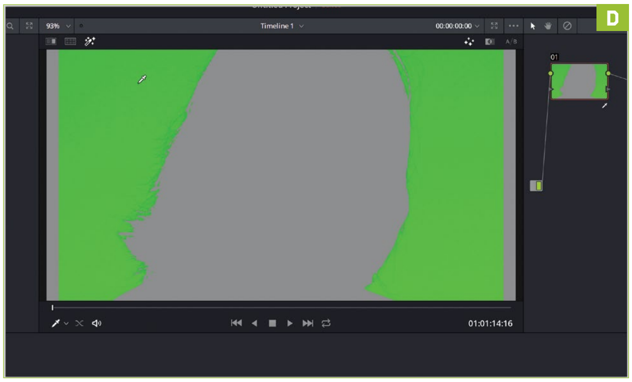
Quality: ○ Automatic Best

DaVinci Resolve File Edit Trim Timeline Clip Mark View Playback Color Nodes Workspace Help
Render Settings
Tape
Clips
Custom
720p
720p
Final Cut Pro 7
Premiere XML
Browse
Video
Audio
File
Add to Render Queue
Untitled Project
Timeline 1
Render Queue
Job 1
Job 2
Job 3
Job 4
Job 5
Untitled Project | Timeline 1
Start Render
01:01:14:16
H.264
H.264
H.264
PNG
Render
In/Out Range

Completed your video? Then it's time to deliver it—or, at least, it's time to use Resolve's "Deliver" section to render it. It's another portion of the program that's intuitive once you get the hang of it, but utterly alien until you do. Head to the "Deliver" section by hitting Shift-8, and you'll see your timeline, a preview of the complete video, and a few more controls. If you're happy that you've edited your video to the point that it's ready to go, choose your settings in the top-left panel—there are presets, usefully, for things such as YouTube—then click the "Browse" button to set where your video will be saved. Now click "Add To Render Queue," and hit "Start Render" on the right-hand side.

If you're only using Resolve to process clips for use in another editor, use the "Individual Clips" radio button in the left-hand pane to render each element individually. And if you've (sensibly) left small gaps at the start and end of your video, you can ensure it comes out at exactly the right length by changing the render to "In/Out Range" (at the top of the timeline), and using the gray bar above the timeline to set the exact point at which you'd like your video to be cut.

screen shot, make sure your lighting is consistent, your surface as flat as possible, and your camera set with enough saturation that the green doesn't tend toward the gray. Head back to the timeline section, and clear it off by dragging a box over all the clips within, and hitting Delete, then place the green screen footage on top of whatever background footage you'd like to use—head back to the "Media" section to import it, if you've not done so already. If you're using the same source file as us, you'll notice that it comes as a series of png files; Resolve treats these the same as it does videos, so rather than importing it frame-by-frame, drag the folder into the bottom pane. Our clip has a slight issue: it's anamorphic, so it looks squashed. Select the clip in the bottom pane, then select "Clip Attributes"—setting "Pixel Aspect Ratio" to "16:9" worked to pull our clip to the correct scale.

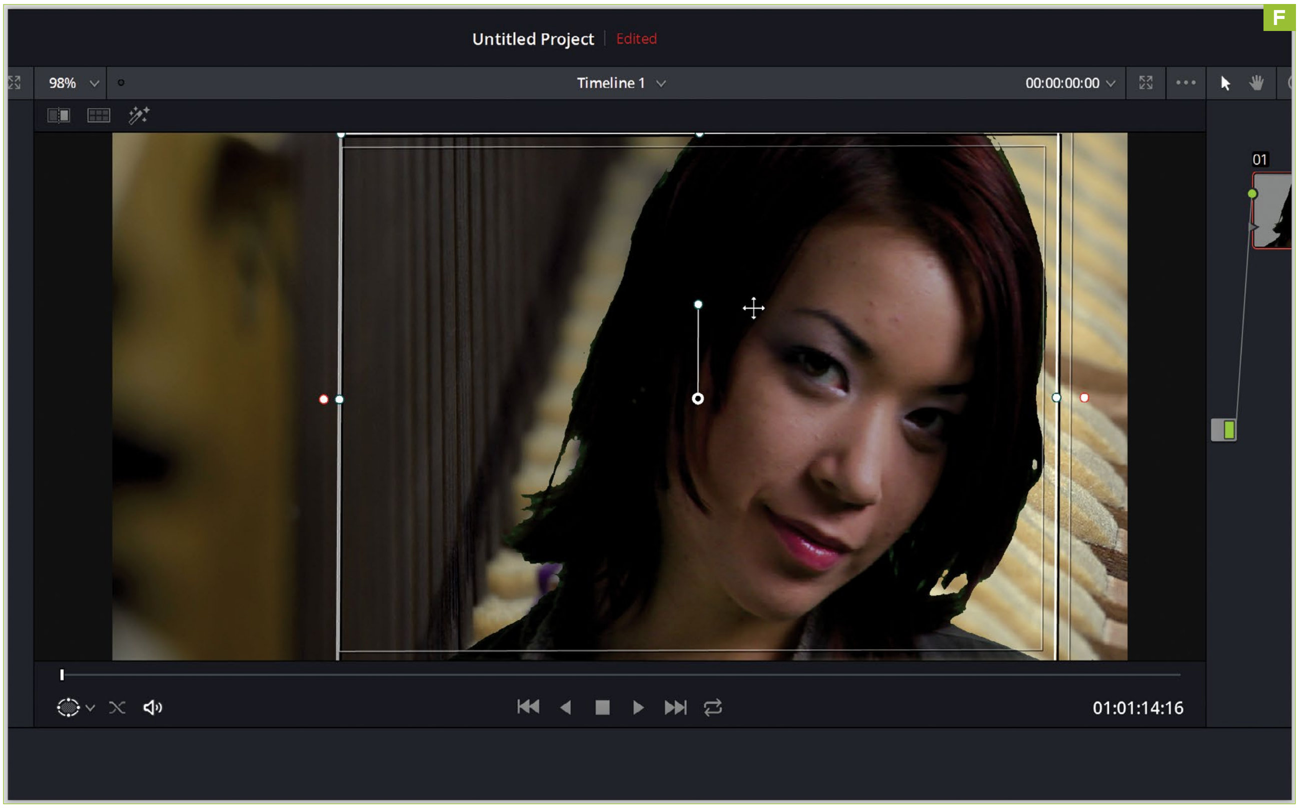


D

93%
Timeline 1
00:00:00:00
01
01:01:14:16

8 SEE THE RESULTS

Head back to the "Edit" section, and layer up a couple of clips, placing the green screen footage on top of your background. Use the preview window to ensure that you can see the green screen footage, then head to the "Color" section. Click on your green screen footage to show it in the preview window, then add a new serial node by hitting Alt-S. Click the eyedropper tool (the Qualifier) on the menu in the center of the screen, then click an area of green screen to select it. Not much seems to have changed, but click the sparkling magic wand icon above the preview, and you'll see that Resolve has created a mask [**Image D**], based on your selected color. At the bottom of the screen, under "Selection Range," clicking the rightmost icon inverts the effect—because we're looking to keep the foreground, rather than the background—and you can see how well you've done. Click and drag the values beneath hue, saturation, and luminance [**Image E**] in the Qualifier window to increase the range of color you're selecting, which should (hopefully) pull your chroma key much closer

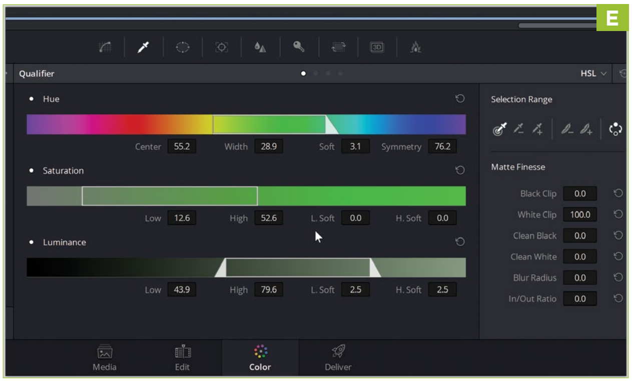


F

to the content you wish to keep visible. In our case, it hasn't worked well, because the green background is massively over-saturated.

9 COLORATION

We need to bring that color down a little before our chroma key will work. Right-click the second node in the top-right pane, and select "Create serial node before." On this node, linked in the chain prior to our chroma key operation, we'll adjust the clip's coloration, so click it to start editing it. There's a problem, of course: if we just pull out a load of green from the clip, our cut-out subject starts to look purple and unwell. But we can be more selective than that. Toward the bottom-left, click the icon that looks like a dot inside a circle to find the color wheels, then head to the third page. Drag the slider below the "Highlight" wheel, and you'll start pulling down the brightness of the background, leaving the main image intact. Click on the original node, and drag the same slider back up a little, which should correct any disturbance to the original image. Make no mistake, we're hacking here. There's no adding quality to poor footage, and the green screen clip we're using is supplied because it presents challenges; if you're using your own stuff, you may not find it as difficult to work with. Sometimes, you just have to do the best job you can, and that means a lot of manual tweaking. Thankfully, pretty much every tool in Resolve's Color section has a reset button, so you can try your tweaks, and undo them quickly.



E

Hue: Center 55.2, Width 28.9, Soft 3.1, Symmetry 76.2

Saturation: Low 12.6, High 52.6, L. Soft 0.0, H. Soft 0.0

Luminance: Low 43.9, High 79.6, L. Soft 2.5, H. Soft 2.5

Black Clip 0.0

White Clip 100.0

Clean Black 0.0

Clean White 0.0

Blur Radius 0.0

In/Out Ratio 0.0

10 QUALIFICATION

Click the node with the chroma key applied to it, make sure the Qualifier tool is selected in the bottom-center pane, and drag the blur radius to increase its value slightly. Don't go crazy, but apply at least a small amount, which will go some way to offsetting the harsh lines often present around the edge of a keyed image. Now it's time to take a look at our results. In the nodes panel, right-click, and select "Add Alpha Output," then click and drag a line between the triangular output of the rightmost node to the blue item that's appeared. Switch off highlight mode by clicking the magic wand above the video preview, and the mixed picture appears. You may want to move the overlaid element; this is ridiculously easy. Just find the sizing tool on the central menu (third from right), and drag the values to move, rotate, or skew your overlay. The edges of the overlaid image block out the background, so head to the window tool (third from left), and click "Linear" at the top to draw a box around your image, and use it **[Image F]** to clip the edges. If you have a poorly keyed background—perhaps with inconsistent green screen, or other elements you don't want in shot—the window tool is a perfect way to get rid of them. So here we are—you've been given a glimpse of Resolve's power, and we've spent four pages merely skimming the surface of what it can do. Head to the "Help" menu to open its reference manual, where over a thousand pages of instructions await you.... ⏻

Make Your Own License Plate

YOU'LL NEED THIS

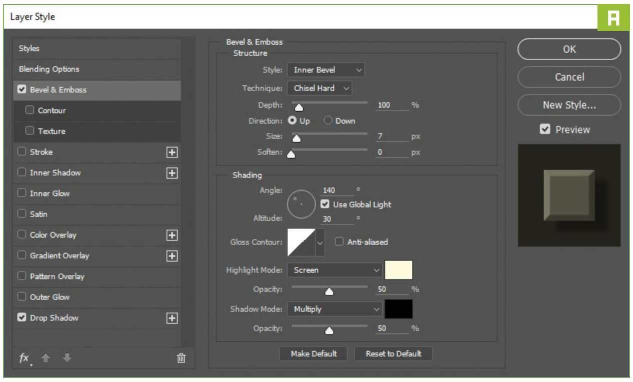
PHOTOSHOP
Subscribe at www.adobe.com.

LICENSE PLATE
As an example to follow.

Vehicle license plates were standardized as the familiar 6x12-inch rectangles in 1956, but they date back to around 1903 in North America, first being used in Massachusetts. Before '56, it was a bit of a free-for-all between the states, with materials such as rubber and leather used to make plates.

Most states emboss the lettering into the plates, so they're slightly raised when viewed from the front, but there is a growing number of flat, digitally printed plates on the highway. If you purchase a vanity plate, you've got a limited number of characters to work with, depending on the state you live in, and there's a list of banned words you need to avoid.

These last two restrictions don't apply if you're designing your own plate in Photoshop, but it's best to stick quite close to the requirements. Once you've made your plate, you can include it in digital art projects, or use it for whatever online persona you're currently rocking, but we don't recommend using a 3D printer to create cover for your bank heist getaway car. **–IAN EVENDEN**



Bevel & Emboss
Structure
Style: Inner Bevel
Technique: Chisel Hard
Depth: 100 %
Direction: ● Up ○ Down
Size: 7 px
Soften: 0 px
Shading
Angle: 140 °
☑ Use Global Light
Altitude: 30 °
Gloss Contour: ☐ Anti-aliased
Highlight Mode: Screen
Opacity: 50 %
Shadow Mode: Multiply
Opacity: 50 %

1 CREATE A NEW DOCUMENT

As the standard plate is in a 2:1 aspect ratio, that's the size we're making our document. We've gone for 1000x500 pixels, with a transparent background. We're going to leave a border around the outside, so our finished plate will be slightly smaller. The color of a license plate is off-white, so click on the foreground color below the toolbar, and enter R=233, G=233, B=233 to make something about the right color. Experiment to see the effect that changing the R, G, and B values has if the color doesn't look right to you.

2 RASTERIZE YOUR RECTANGLE

For the plate's outline, we're going to make a rounded rectangle. In Photoshop CC, fold out the Rectangle tool, and you'll find a "Rounded Rectangle" option. In earlier versions, you may need to use a Custom Shape, and select "Rounded Rectangle" from the options bar. Set the corner radius to 40 pixels (this number varies depending on the size of your document, so see what looks right for you), and the aspect ratio to 2:1. Draw your rectangle, then use the Bucket tool to fill it with your foreground color—it asks whether you want to rasterize the shape, and you do.

3 MAKE IT LOOK 3D

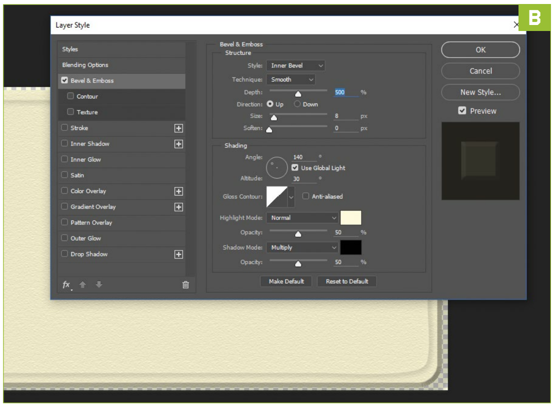
To give the plate background a 3D look, apply some beveling. Right-click the "Rounded Rectangle" layer, select "Blending Options" to bring up the "Layer Style" window, and add a drop shadow, with the light source coming in from the top-left. Check the "Bevel and Emboss" box, and add an "Inner Bevel" using the "Chisel Hard" technique, to give the corners some texture. Hit "OK" [**Image A**]. For more texture, open the "Rounded Rectangle" layer in Filter Gallery, and select the "Texturizer" filter under "Texture." "Sandstone" with a "Relief" setting of 2 gives a roughened look.

4 CREATE THE RIM

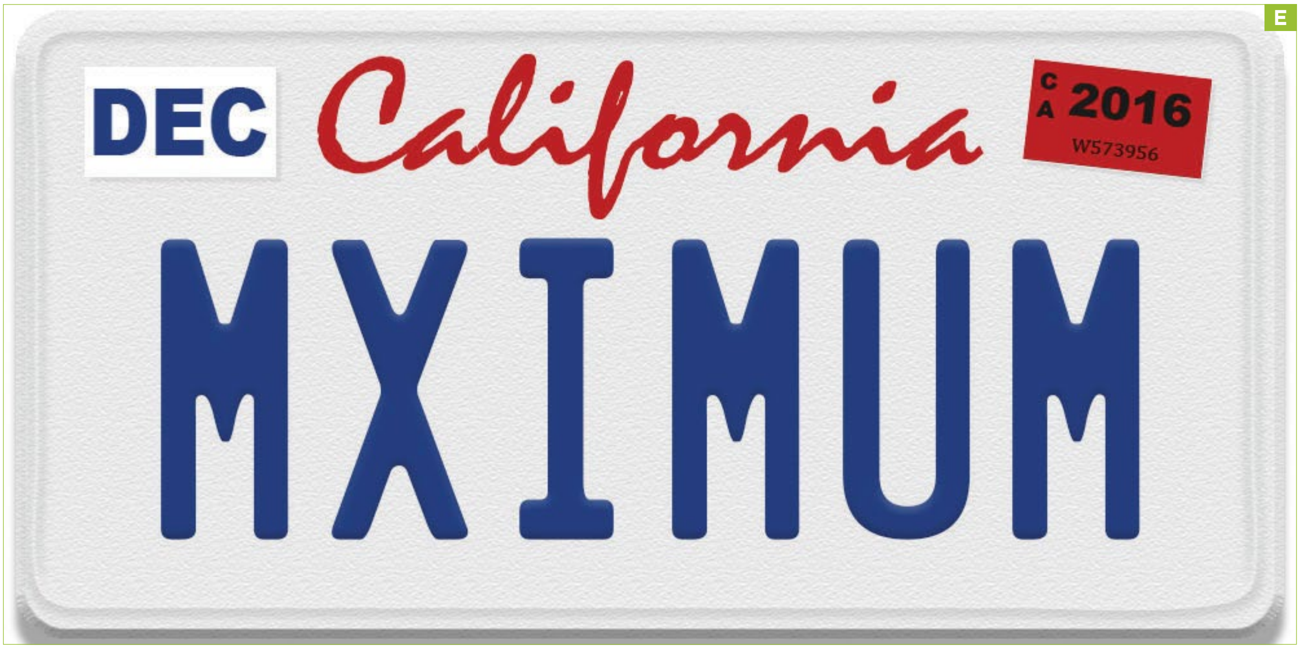
License plates have a rim, which means more beveling. First, though, we need to select the area to be beveled. Right-click the "Rounded Rectangle" layer, and choose "Select Pixels," then "Select → Modify → Contract," and move it in by 20 pixels or so. Nudge the outline with the arrow keys so it's central. Then open the "Paths" palette, and convert your selection to a path. Choose the "Brush" tool, diameter 20px, and make your foreground color black. Create a new layer and select it. Stroke the path with the brush (right-click the "Work Path" in the "Paths" palette), and you should get a black hoop around your plate, but on a separate layer. Open the "Layer Style" palette again, and change the layer's blend mode to "Screen," at around 25% opacity. Now apply a "Smooth Inner Bevel," with a depth of 500%. You now have your rim [**Image B**].

5 ADD THE LETTERING

It's time to add the lettering. You need the right font, and there's a couple of different ones available for free online if you search, mostly with names like "License Plate." Put some thought into your choice of lettering,



Bevel & Emboss
Structure
Style: Inner Bevel
Technique: Smooth
Depth: 500 %
Direction: ● Up ○ Down
Size: 8 px
Soften: 0 px
Shading
Angle: 140 °
☑ Use Global Light
Altitude: 30 °
Gloss Contour: ☐ Anti-aliased
Highlight Mode: Normal
Opacity: 50 %
Shadow Mode: Multiply
Opacity: 50 %


E

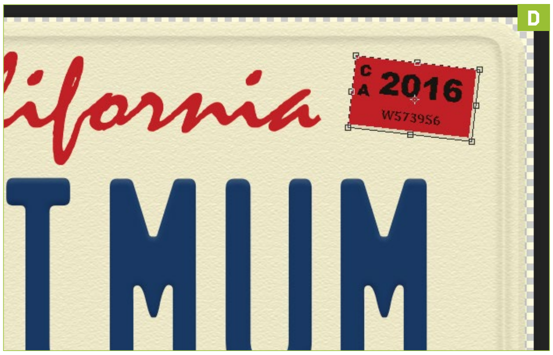
trying to stay within the character limit, which varies between states, but is often six or seven. Earlier this year, a North Dakota resident had their "X32TTU8" plates revoked when some killjoy read them backward, but we have no such worries with ours. The lettering is often blue, something like R44, G61, B127, and we used 300pt. Because our HQ is in San Francisco, we're going to make this a California plate.

6 STATE YOUR STATE

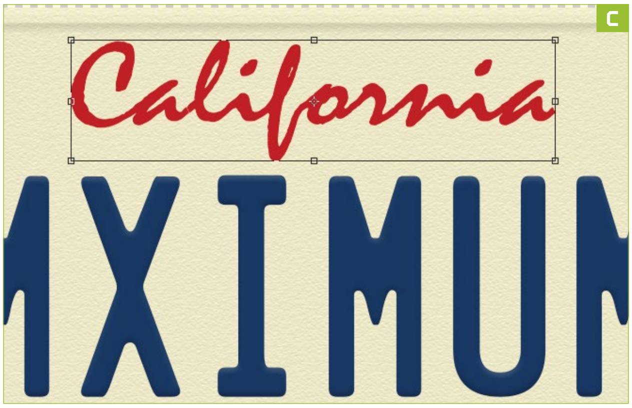
California uses a hand-drawn font for its state name, and it's almost but not quite the same as Mistral, a font you can find online. The word "California" is slightly wider than four of the characters below it, which on our plate comes out at around 150pt [**Image C**]. Once you've typed it, choose a suitable red (R189, G0, B0 for us), and rasterize the layer by right-clicking the layer, and selecting the option from the menu. Go to "Edit → Transform → Free Transform," and squash the lettering slightly, so it's not so tall. Reposition your lettering below it if necessary, but keep it all inside the rim of the plate.

7 FINISHING TOUCHES

We're not going to create screw holes in ours, but you can use the "Circular Marquee" tool, and punch four circular holes through the background layer. To add stickers, use the


D

"Rectangular Marquee" on a new layer to create white and red areas—whatever matches the state you're copying—and use "Layer Styles" to make drop shadows under them. Add the text using the "Type" tool, and appropriate serif and sans serif fonts. We've rasterized and merged the type layers into the red sticker's background, then used "Free Transform" to skew it, as these things are impossible to get on straight [**Image D**]. Once we've saved our plate, and exported it as a JPEG [**Image E**], it's time for our executive editor to start compositing it into pictures of his Camaro.


C

LAYER EFFECTS

Using the "Layer Style" window, you can apply multiple effects to your layers. An "fx" symbol appears next to the layer in the stack, and the effects drop down below it. If you haven't rasterized the layer, you can turn individual effects on or off at will by clicking the eyeball icon, just as you would the layers themselves. The palette we've been using here allows you to create your own effects from the tools provided, but there are also presets, accessed by going to "Window → Styles." You can change how effects interact by changing their order in the "Layer Style" window—select an active effect, and use the arrow buttons, bottom-left, to change the order.

BUILD IT

ZAK STOREY, REVIEWS EDITOR

The Linux Budget-Busting Box

Making Linux great aga... Just kidding!

LENGTH OF TIME: **1–2 HOURS**

LEVEL OF DIFFICULTY: **EASY**

THE CONCEPT

"LINUX" IS A FAIRLY TABOO word for most here at *Maximum PC,* yet we write about it a lot—and with good reason. It's a free, diverse, open-source operating system, with a huge breadth of potential. It rattles the cages of the likes of Microsoft and Apple, and constantly helps to improve the technological ecosystem we all call home. However, due to the very nature of the beast, the fact that it's easy to get hold of a free copy of the rebel OS, and most of its users are more inclined to run older hardware, the vast majority of Linux-powered systems tend to err on the side of caution when it comes to purchasing newer hardware. So, for many people, the concept of a super-fast Linux system, powered by the latest Intel Z170 chipset and M.2 PCIe SSDs, is something of an oxymoron.

The plan with this project, then, was to satisfy two separate criteria. Firstly, to build a super-fast Linux system, powered by a quad-core Intel processor in conjunction with the latest Samsung M.2 PCIe SSDs, and secondly, to keep the budget as low as humanly possible at the same time, to stick to the Linux ethos. Did we achieve it? Almost.

THE LINUX DREAM

TO START WITH, WE KNEW we wanted to use a quad-core processor, preferably of Skylake origin. The newer chipsets would support M.2 drives over the PCIe bus, and the four cores of Skylake's mighty Core i5-6500 would be plenty for any demanding Linux task we could throw at it.

For a base hard drive, we opted for a Samsung PM961 256GB M.2 PCIe SSD. Coming in at a relatively cheap $144, this OEM drive boasts a whopping 3,000MB/s sequential reads, and 1,100MB/s sequential writes, proving to be one of the best deals around when it comes to current NVMe drives. However, as it's an OEM drive, it's worth bearing in mind that you'll receive no support from Samsung with regard to drivers, troubleshooting, or software issues. That said, as it's primarily only going to be used for the OS, that's not the end of the world.

Our motherboard was a cheap and cheerful Asus B150 A/M.2. At the low end of the pricing spectrum, it's a fairly well-equipped mobo capable of housing 8GB of DDR4, in conjunction with an M.2 drive, and a plethora of SATA drives. And our last worthy mention is the 550W Kolink budget power supply, which we scavenged from our storage containers. It's not available to buy right now, but swapping it over to an EVGA 500B would be more than enough to satisfy all your power needs—even with an additional GPU—without breaking the bank.

INGREDIENTS

PART		STREET PRICE
Case	BitFenix Nova ATX mid-tower case	$61
Motherboard	Asus B150M-A/M.2 Micro ATX	$67
CPU	Intel Core i5-6500 @ 3.2GHz	$196
Memory	Team Elite Plus 8GB (2x 4GB) @ 2,400MT/s	$51
GPU	Integrated graphics	$0
PSU	EVGA 500B	$43
Storage 1	Samsung PM961 256GB M.2 PCIe SSD OEM	$144
Storage 2	Western Digital Blue 2TB 5,400rpm HDD	$70
Total		$632

1

REAR I/O PLATES

WHENEVER YOU START building any system, the first thing you should do (after stripping out everything you don't need from the case, of course) is install the rear I/O plate. On the more expensive boards out there, these are nicely designed, clean plates, with protective EMI-shielded padding. However, on the more budget-focused boards, you may find they are simply a thin sheet of tin, with a variety of pins sticking in place. Our best piece of advice is to try to bend these out of the way so you can install your motherboard securely afterward, and if that fails to work, snap the extra metal pins off entirely to make sure you keep everything installed in place. Rear I/O plates keep the vast majority of dust out of your system.

2

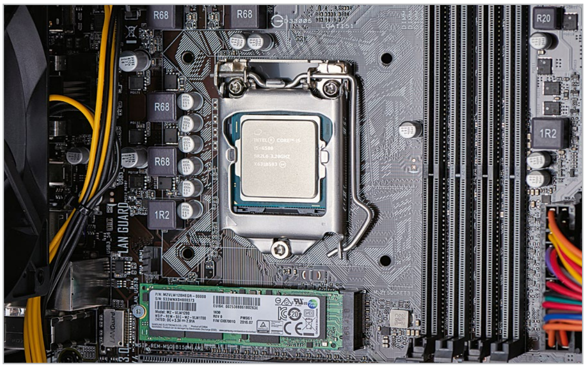
CABLE MANAGEMENT

FOR THIS BUILD, WE OPTED to use one of BitFenix's Nova cases. Generally speaking, BitFenix makes some fantastic budget-oriented chassis, which beside looking good, generally make our lives a little easier when it comes to constructing a system. You can find these for about $50 here and there, but we opted for the slightly pricier $65 windowed variant. Cable management is slightly limited in these budget-friendly models, but we still managed to route the PSU cable up and through the rear of the chassis. Although this doesn't do much to make things look any tidier, it does help keep the cable out of the way of any graphics cards you may wish to fit in the future. We just wish we could say the same for the 8-pin CPU power.

3

CPU & M.2 INSTALLATION

INSTALLING A CPU IN THE SKYLAKE ERA is exceedingly easy. Simply lift up the metal retention lever located to the right of the socket, leaving the plastic protector in place. Place the CPU gently into the socket, with the golden triangle on the processor pointing in the same direction as the triangle mark on the retention bracket, slide the bracket back under the screw, and relock the retention arm. The protective cap should pop off, and you're all set. Word of warning for the less experienced: Do this on a flat surface, with the motherboard laying flat. You can do it inside a chassis, but just don't do it vertically. For M.2 SSDs, simply undo the screw located near the end of the M.2 slot, put the drive in the correct way (matching the slot up with the drive), press the drive down, and rescrew in place.



4

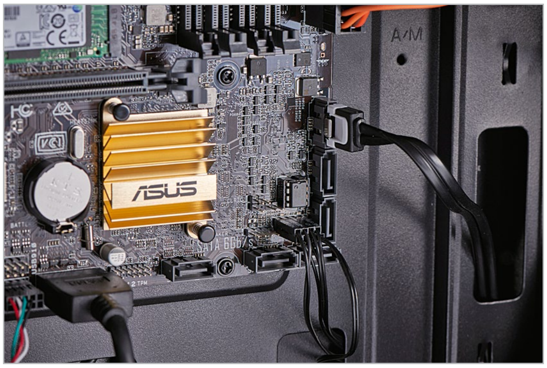
FAN ORIENTATION

WHEN IT COMES TO BUDGET CASES, included fans tend to be pretty sparse. With the Nova coming with just a single 120mm airflow fan, we opted to reverse it and use it as an intake for the whole system, as opposed to an exhaust. Although this won't necessarily help a huge deal with dust control, drawing cool air in directly over the reference cooler, and down on to the motherboard, should help to alleviate any potential thermal throttling issues. That said, with the clock speed on the Intel Core i5-6500 only registering at 3.2GHz, and thanks to Skylake's exceptionally power-efficient architecture, it's highly unlikely we'd ever reach a point of thermal throttling, even with a stock cooler running at full load.

5

FRONT I/O CONNECTORS

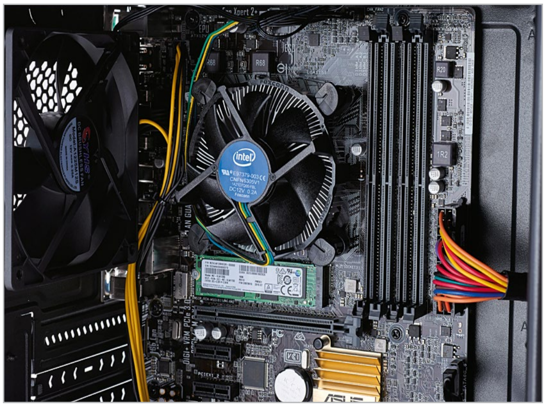
THERE'S NOTHING MORE FRUSTRATING to deal with than front I/O connectors. These fiddly cables ensure that all your power buttons, reset switches, and LEDs work effectively, but attaching them to the motherboard can be a pain in the proverbial. If your motherboard doesn't have directions printed on it for what goes where, you'll have to dive into the user manual. Fortunately, for the Asus B150 A/M.2, the instructions are printed on the PCB around the front panel connectors. Our advice? Try to route the connectors through a rear panel to manage the mess, and ensure that the positive and negative sides of your LEDs are attached to the correct points, otherwise they won't operate.

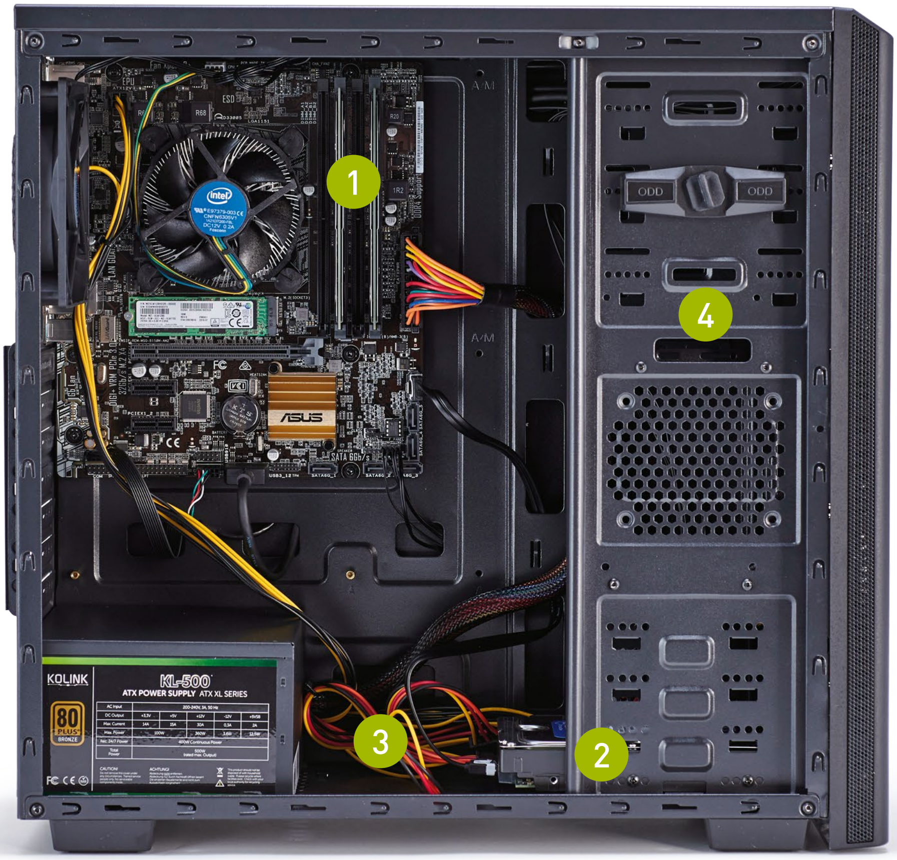


6

CPU POWER

IN CASES LIKE THE NOVA, cable management space behind the rear panel is often an afterthought. This can make installation of the CPU 8-pin power particularly troublesome. Fortunately, in this build, thanks to the lack of add-in cards, we could run the CPU power straight up and across the board, taking care not to hit the stock cooler. If you were running a graphics card as well, however, a neat way of getting around this problem would be to install the PSU first, then route the CPU cable under the motherboard itself, taking care not to get in the way of any stand-offs. It can be a bit fiddly, but it's a neat way to keep a cable tidy, while simultaneously allowing GPUs to be installed.





① The 8GB of DDR4 here is rated to operate at 2,400MT/s—it's worth noting that the B150 chipset can only support 2,133MT/s max.

② Although a 2TB drive does bump up our overall spend, we wanted to create a versatile Linux box, regardless of whether you want to game, work, or stream media from it.

③ There's actually a chunk of cable management just to the left of the hard drive cages, facing forward—we wedged a swathe of excess cables there to keep things looking a little tidier.

④ BitFenix even manages to include a toolless 5.25-inch drive bay for those still clinging on to their old Linux discs.

A LOVELY LINUX EXPERIENCE

FOR THIS REVIEWS EDITOR, it's safe to say that Linux is a completely alien experience. Getting to grips with it certainly made for an interesting struggle. As a hardcore Windows fan, the concept of running the entire OS off a single bootable USB stick was mind-blowing. The versatility achieved by having the OS on a single drive to diagnose potential future hardware problems is nigh on incredible, especially compared to an OS like Windows, where everything is tied down into authentication, personal accounts, and Windows Updates.

That wasn't the only thing that impressed, however. The level of customization available upon installation was equally mesmerizing. Did you want to use a virtual partition system ahead of time? Fine. Encrypt the drive's OS and drive entirely? OK. And there are many other options equally possible on the portable desktop. Couple that with the ridiculously small install size, and it really is something worth trying, at least once, even by Linux's harshest critics.

The thing is, Linux users are to operating systems what we enthusiasts are to hardware. They're the tinkerers, the command-line delvers, those looking to tailor their desktops to exactly what they want to do. Whether that's an office PC, a gaming rig, a NAS, a Plex Media Server, hell, even a mobile drone—all of it can be done through a variety of different distros ready to serve the user, most of which are free, and all of which are open source.

And it's that open-source heritage that makes the OS so much more in tune with the market than even Windows can manage. 4K scaling by default is a given, the user interface is intuitive and easy to use, and the best features from both Windows and MacOS are seamlessly integrated by default. That's not to say it's not without its problems, of course. Driver support is unbelievably patchy, and even running an AMD processor provides its own set of challenges. AMD GPU drivers are included in most distros by default, but Nvidia generally performs better once the driver is installed. Having to perform tweaks for any serious problem via the command line can become tiresome, and even having to learn how a new operating system works can be frustrating at times.

Naturally, as far as performance goes, with the Samsung PM961 operating alongside the Intel Core i5-6500, it was certainly quick to boot. Lightning-fast, in fact. File transfer speeds were well into the 3GB/s range on the primary drive, with Cinebench R15 providing an impressive score just shy of 620 points—what we'd expect from a core like this. Alas, that's where our performance charts end. Benchmarking games in Linux is challenging, if not impossible. Games such as *Shadow of Mordor,* do boast an integrated benchmark, but showed a 50 percent decrease in overall average frames per second compared to the same hardware running Windows. For the most part, what we can say is that Linux does support Steam, and more games are slowly threading their way into the OS. But gaming isn't really what Linux is about.

Experience and performance aside, the build process itself was incredibly painless. This is the absolute basics of PC building: Take a case, grab a processor, a standard PSU, two sticks of RAM, and a few hard drives, and just slap it all together. There are no back plates to attach, no internal cooling to worry about, and no particular need for aggressive cable management. What you're left with is an astonishingly quick build with relatively little fuss, that performs exceptionally well, regardless of what platform you happen to be on. ⏻

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FALCON NORTHWEST TIKI
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Asus Strix GeForce GTX 1050 Ti

It just doesn't make any sense

NVIDIA'S GEFORCE GTX 1050 TI is a rather curious concept. It follows a long line of prestigious graphics processors with its nomenclature—from the PCI powerless GTX 750 Ti, to the value-demolishing 950—yet this variant just doesn't seem to have hit the same mark. It still requires that six-pin PCI power connector, and it doesn't quite reach the heady heights of glorious frame-rate-to-dollar ratios that we want when it comes to price, either.

So, where shall we begin? Let's start with the spec. Nvidia's GeForce GTX 1050 Ti comes with 768 CUDA cores, 48 texture units, and 32 ROPs. In contrast, the previous generation had 768 CUDA cores, 48 texture units, and 32 ROPs. "Well, of course, it's a process shrink," we hear you say, "So nothing else is bound to change." We'd be inclined to agree, if it wasn't for how the rest of Nvidia's lineup has evolved this past year. Compare the 1060 to the 960, and the number of cores has expanded from 1,024 to 1,280, with transistor count increasing by 1.46 billion in the process. The 1050 Ti, on the other hand, has a meager transistor increase of just 0.36 billion. You see where we're coming from here? The problem is, that it shows, terribly so. And when you consider the price of the GTX 1050 Ti—even with the 4GB variant versus the 3GB GTX 1060—well, you've got to be asking yourself some serious questions about why you would want to sacrifice that extra processing power.

On to performance figures, then. At 1080p, this card achieved 43fps on average in *Far Cry Primal*, contrasting starkly with the GTX 1060 3GB's 61fps. In *Attila*, the difference was less pronounced, with the plucky underdog losing out by 13fps, but in almost all the other titles, the difference was astronomical. In fact, it was so bad, it forced us to reach back into our archives to see how well the GTX 960 scored in synthetic benchmarks compared to the 1050 Ti. The answer? The 960 scored just 200 points less in Fire Strike than this new 16nm card. Ouch. Power draw, on the other hand, is more in line with what you'd expect from a card of this caliber—overall draw from the wall staying resolute at 216W under maximum load, and 52W at idle.

IT'S NOT ALL BAD

Pushing the GPU aside for a moment, let's look at this card in isolation. Asus really has nailed it with this iteration. It isn't the triple-fan, galvanized concoction of metal and RGB LEDs that we find on cards higher up in the series, but a dual-fan solution, with a far smaller overall footprint, produced in a much more stylish manner. Don't get us wrong, the DCIII is great at reducing overhead temperatures, but the added length puts many folk off. The dual-fan solution here, on the other hand, looks crisp, clean, and sharp, and the added backplate adds to the premium feel. The fans are quiet—almost silent—while spinning at low loads, with 0dB fan technology included to reduce noise while idling on desktop. It's almost as though the AIBs have been let down by the GPU.

Ultimately, if you were to evaluate this card outside of the GPU ecosystem, you'd be pleased with its performance. At 1080p, it can easily hit 30–45fps in most modern titles. However, comparing it to the GTX 1060, which is only $20-50 more in some scenarios, or even the RX 470, at just $5 more, it's hard to justify this card's position in the market. We recommend the RX 470 Strix 4GB or the low-end GTX 1060 instead. As an aside, due to the supply and demand issues that Asus is currently experiencing, we've been informed that the high price of this specific card will be dropping over the coming months. **–ZAK STOREY**

VERDICT 6

Asus Strix GeForce GTX 1050 Ti

+ SUCCESSOR Super-low power draw; acceptable performance at 1080p; quiet; card looks great.

− SQUALOR Poor price-to-performance; incremental update on last gen.

$180, www.asus.com

BENCHMARKS

	Asus Strix GTX 1050 Ti	EVGA GTX 1060 3GB	MSI RX 470 4GB
Total War: Attila (fps)	14/23	**24/36**	21/28
Far Cry Primal (fps)	34/43	**49/61**	44/54
The Division (fps)	19/36	31/**55**	**36/55**
Rise of the Tomb Raider (fps)	**9**/23	**9/35**	**9**/31
3DMark Fire Strike (Index)	7,042	**10,251**	10,135
Power Draw (Watts)	**216**	251	285

Best scores are in bold. Game results are minimum and average fps at 1440p. Our test bed consists of a Core i7-6700K, 16GB of DDR4, and an MSI Z170A Gaming M7 motherboard.

SPECIFICATIONS

GPU	GP107
Lithography	16nm FinFET
Transistor Count	3.3 billion
CUDA Cores	768
Texture Units	48
ROPs	32
Core/Boost Clock	1,290/1,392MHz
Memory Capacity & Type	4GB GDDR5
Memory Bus	128-bit
TDP	75W
Display Connectors	DisplayPort 1.4, HDMI 2.0(b), 1x DVI

So smexeh, but at what cost?

Falcon Northwest Tiki

A mighty beast in a tiny frame

IT'S NO SECRET that buying a custom-built system from a professional PC builder comes with a premium price. Normally, we are staunch advocates of building your own PC, but it's worth considering a custom builder for small form factor systems. The Falcon Northwest Tiki is a perfect example.

Measuring just 13.75 x 14.5 x 5 inches, including the base, the Tiki's shiny bespoke chassis takes up a minimal amount of desk real estate, giving you reason to display its edges, rather than hide it away under your desk. But assembling parts inside such a small space can be quite the hassle, especially when you want to cram a full desktop's worth of power inside.

Removing the Tiki's side panel feels a little like peering into a desktop-class laptop, where every component has its proper place, and not a bit of space goes to waste. This allows for an Asus Z-series Mini-ITX motherboard to host an Intel Core i7-6700K and 16GB of RAM—fairly standard fare—as well as a full-size Nvidia Titan X, connected via a PCIe flexible ribbon in order to sit parallel to the mobo. Top that off with a 512GB Samsung 950 Pro M.2 SSD, combined with a 4TB Western Digital Red HDD, and you can see that the Tiki packs a lot of power into its rather svelte frame.

The Tiki's crowning component is obviously the top-end Titan X. Nvidia's Pascal architecture brought outstanding performance to its whole slate of current-gen graphics cards, and the Titan X sits at the top of that pile. In our 1080p testing, the Titan X's 12GB of VRAM proved more than enough for exceptional frame rates, pulling in around 120fps for *Far Cry Primal* and *The Division*, and an average of 158fps across *Rise of the Tomb Raider's* three-part GPU benchmark.

SMALL BUT MIGHTY

Interestingly, these numbers show that a single Titan X performs both better and worse, depending on the game, than a pair of GTX 1080s—such as the configuration found in the full-tower Digital Storm Aventum 3 that we reviewed way back in our September 2016 issue. There isn't much price difference between the two configurations, and for larger systems, we'd say that dual-1080 is likely the better option. But, for the Tiki's small form factor, it's nice to see that the single, more powerful card can hold its own.

The Tiki also performs admirably at higher resolutions. The Tiki's Titan X managed a fairly stable 46fps for *The Witcher 3* in 4K with max settings. While not quite the gaming ideal of 60fps, Geralt looked absolutely stunning in 4K, and our test monitor's G-Sync kept everything smooth. *Rise of the Tomb Raider* landed at 97fps in 1440p and 50fps in 4K, while 3DMark's 1440p and 4K tests, Fire Strike Extreme and Ultra, returned scores of 11,526 and 6,296, respectively.

On the computational side, the Tiki lagged slightly behind in tests such as Cinebench R15, Tech ARP x264, and PCMark 8 Creative, compared to builds outfitted with the enthusiast-level Core i7-6950X. Having said that, its Core i7-6700K is certainly no slouch, and is more than powerful enough for any task you choose to throw at it.

As configured, the Tiki we tested was knocking on the door of $4,000—a hefty price tag, but not unreasonable considering the power contained within its small frame. Falcon Northwest's build quality is top tier, and while there isn't much room inside the Tiki's frame for upgrades down the road, the power it ships with should last for a long, long time. **–BO MOORE**

VERDICT
9

Falcon Northwest Tiki

+ TIKI TORCH Compact; powerful; beautiful design.

− ANGRY GOD Heavy; expensive; RAM is lacking; limited upgrade potential.

$3,953, www.falcon-nw.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 (Index)	987	990 (0%)
Tech ARP x264 (fps)	21.93	21.94 (0%)
CrystalDiskMark 4K Read (MB/s)	54.85	50.96 (-7%)
CrystalDiskMark 4K Write (MB/s)	171	235.23 (38%)
Far Cry Primal (fps)	76	121 (59%)
The Division (fps)	78	120 (54%)
Rise of the Tomb Raider (fps)	41	158 (285%)
3DMark Fire Strike (Index)	15,026	20,410 (36%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point has a Core i7-6700K overclocked to 4.6GHz, an XFX Radeon R9 Fury X, 32GB of Kingston HyperX Savage DDR4-2400, and a 256GB Samsung 950 Pro, mounted on an Asus Z170i Pro Gaming mobo.

SPECIFICATIONS

Processor	Intel Core i7-6700K @ 4.2GHz
Graphics	Nvidia Titan X Pascal
RAM	16GB (2x 8GB) G.Skill Ripjaws4 2,400MT/s DDR4
Motherboard	Asus Z170i Pro Gaming
Primary Storage	512GB Samsung 950 Pro M.2 PCIe NVMe SSD
Additional Storage	4TB Western Digital 7,200rpm Red
Cooling Solution	Asetek 550LC 120mm
PSU	Silverstone SFX 450W
Case	Custom Tiki chassis
Warranty	Three years

The Tiki's single Titan X holds its own against larger, dual-GPU builds.

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WD My Cloud Pro PR2100 16TB

Versatile storage for the cloud generation

THE POPULARITY of network attached storage is succinctly illustrated with this latest release from Western Digital: The WD My Cloud PR2100 is essentially an upgraded take on last year's My Cloud Business DL2100—a device that was aimed squarely at small businesses. This new device uses the same chassis, with its austere and utilitarian drive bays, but updates the innards so that it can handle 4K streaming. It's a device that's serious about your data, but appreciates that you're just as likely to use it in the home as you are in the office.

The My Cloud PR2100 is a dual-drive unit, although the PR4100, a four-bay device, is also available. Both units boast the same core hardware of a quad-core Intel Pentium N3710, coupled with 4GB of DDR3. This CPU has a base frequency of 1.6GHz, capable of bursting up to 2.56GHz if needed, although it's the low TDP of just 6W that's possibly more noteworthy—you'll rarely call on the full performance of the chip, but you will leave the unit plugged in 24/7. In testing, it pulled just 22W from the wall, which is impressive.

One thing that we noted with the original DL2100, and something that continues to grate with this model, is how noisy it can be. We're not talking about the bump and grind of the hard drives, which isn't much more noticeable than other NAS units, but rather the whine of the fan at the rear of the unit. This is loudest when it's first turned on, but revs up at other times, too. It could well limit where you place the NAS.

On the positive side, this device is incredibly easy to set up: Plug it in, connect it to your router, turn it on, go to the My Cloud website, and you're up and running. The main drive interface is simple but slick, and the homepage clearly shows everything vital you'd want to know about the NAS. Accessing the drive locally is as straightforward as you'd expect, while connecting to it over the Internet is also surprisingly easy, too. Uploading files remotely can be a sluggish affair, but pulling that data off is snappy, and local uploads are much quicker. In testing, we witnessed local read and write speeds of 119MB/s and 118MB/s respectively, which are both very healthy.

DRIVE A BARGAIN

The My Cloud PR2100 is available as an unpopulated device with a list price of $399, but the model we have here ships with a pair of Western Digital's own 8TB Reds. These drives cost $345 each on their own, so buying this drive populated represents reasonable value for money as well. By default, these are configured as a RAID 1 volume, which makes sense for a two-drive device that you're trusting with your data. This gives you 7.93TB of space to play with, and has the reassurance that comes with a mirrored array. This isn't your only configuration option, though, because it supports JBOD, Spanning, and RAID 0 configurations as well.

One particularly nice feature of the My Cloud Pro is the front-mounted USB port that enables you to back up the contents of whatever you plug into it with a touch of the button above the port. It's a simple enough idea, but one that is often overlooked by bigger, cleverer devices. A counter to this is that those bigger, clever devices probably have a more extensive app catalog to call upon. There are 17 apps available for the My Cloud Pro, covering everything from media servers to torrent clients, though—so, for the vast majority of uses, Western Digital should have you covered. A notion that sums up the My Cloud Pro well. **–ALAN DEXTER**

VERDICT 8

WD My Cloud Pro PR2100 16TB

+ **CUMULUS** Versatile connectivity; push-button backups; good performance; reasonable value.

– **NIMBOSTRATUS** Noisy fan; limited software library.

$899, www.wdc.com

SPECIFICATIONS

CPU	Intel Pentium N3710
Cores	4
Speed	1.6GHz (2.56GHz Burst)
Installed Memory	4GB DDR3
Memory Upgradeable	No
OS	WD My Cloud
USB Ports	2x USB 3.0
Ethernet Ports	2x Gigabit
Others	2x power-in (only one adapter supplied)
Warranty	Three years

Does Samsung's 960 Pro spell the end for mechanical hard drives?

Samsung 960 Pro M.2 2TB

The best just got better

WHEN SOLID-STATE DRIVES first arrived, there was much rejoicing. Surely, the PC had crossed the final frontier. All mechanical devices could finally be banished, and with them any performance bottlenecks. The PC's work was done. But it hasn't quite worked out like that.

The first consumer SSDs had some serious performance flaws. Once those were hammered out, SSDs began to bump up against the limitations of the SATA interface and AHCI control protocol. Then PCI Express technology removed that bottleneck, and the NVMe protocol enabled even more responsiveness.

Put another way, SSDs are still getting faster, and that's the context into which Samsung's new solid-state killer arrives, the 960 Pro. Expectations are high, given the outstanding history of Samsung's Pro line of SSDs. Many of them have been the best in the business.

The 960 Pro is effectively Samsung's second generation of consumer-targeted PCI Express SSDs in M.2 format, following the kick-ass 950 Pro, although Samsung did offer a few OEM M.2 drives before the 950 Pro. Whatever, the 960 Pro is pretty much all-new. It uses Samsung's latest Polaris controller chip, for instance. It has also transitioned from Samsung's 32-layer 3D NAND memory chips to 48-layer chips, with double the data density.

The upshot, on paper, is some absolutely stellar claimed performance numbers. The old 950 Pro was far from shabby, with its 2.2GB/s read rating, and maximum IOPs performance of 300K. But the new 960 Pro positively blows it out of the water. The 2TB model reviewed here tops out at an epic 3.5GB/s for reads and 2.1GB/s for writes—numbers that are beginning to resemble system memory bandwidth capabilities from not all that long ago.

The QD32 random access numbers are almost as impressive, at 440K read IOPs and 360K write IOPs. The latter figure is well over three times the official 110K write IOPs of the 950 Pro. As if that wasn't enough, the endurance rating is up, too, and rocks in at a beefy 1,200TB. Admittedly, not all the numbers are as spectacular. Samsung has only managed an incremental improvement in QD1 random access performance. But taken as a whole, it looks like a huge leap over what was already a lightning-fast drive.

In some regards, that's how it plays out in our benchmarks, too. In ATTO Disk Benchmark's raw test of throughput, for instance, the 960 Pro demolishes data at roughly the claimed multi-gigabyte rates. It's much quicker than the 950 Pro in CrystalMark's sequential tests, too. Elsewhere, though, the 960 Pro is very fast, but not as big a step forward as we'd hoped.

It only improves on the 950 Pro's 51MB/s CrystalMark 4K reads by 7MB/s, for example. And it's actually a little slower than the 950 in CrystalMark's 4K write tests. The 960 Pro is likewise barely any quicker in our real-world file copy test than either the 950 Pro or, indeed, Intel's 750 Series 1.2TB drive. We also had the same issues with 4K benchmarking in AS SSD that we saw with the 950 Pro. You could write that off as a quirk with that particular benchmark, but it's difficult to be certain that there aren't real-world workloads that would trigger the same issues.

All of which means it's one of those weird situations where we have a product that's probably faster than anything we've seen previously. At 2TB, it's also a reminder that pretty soon you won't need a magnetic drive for even mass storage duties. And yet, somehow, the 960 Pro leaves us less than totally convinced. It's probably the best drive you can buy at the moment. But it's still not perfect. It's also worth remembering that Intel's 3D Xpoint tech is coming, and might just revolutionize storage technology. **–JEREMY LAIRD**

VERDICT
9

Samsung 960 Pro M.2 2TB

+ STATE OF THE ART Fantastic specifications; mostly awesome performance; huge capacity.

− NOT SO SOLID It's ain't cheap; the performance isn't perfect; Intel's 3D XPoint might be far faster.

$1,299, www.samsung.com

SPECIFICATIONS

Capacity	2TB
Form Factor	M.2
Interface	PCIe 3.0 x4
Memory Type	Samsung 48-layer 256Gb MLC V-NAND
Controller	Samsung Polaris
Sequential Read	3,500MB/s
Sequential Write	2,100MB/s
4K Read	440K IOPs
4K Write	360K IOPs
Endurance	1,200TB
Warranty	Five years

BENCHMARKS

	Samsung 960 Pro M.2 2TB	Samsung 950 Pro M.2 512GB	Intel 750 PCIe 1.2TB
ATTO Sequential Read/Write (GB/s)	**3.4/2.1**	2.6/1.5	2.6/1.4
CrystalMark Sequential Read/Write (MB/s)	**2,636/2,077**	2,210/1,539	1,298/1,271
CrystalMark 4K Read/Write (MB/s)	**57**/194	51/198	37/**326**
5GB Zip (Seconds)	196	**193**	196
30GB Copy (Seconds)	**41**	43	42

Best scores are in bold. Our test bench consists of an Intel Core i7-6700K, MSI Z170A Gaming M7, and 16GB Crucial Ballistix Elite DDR4-2666.

AG271QG
AGON

AOC's AG271QG gives Asus's RoG Swift PG279Q a run for its money.

AOC AGON AG271QG

Have some 165Hz IPS awesomeness from AOC

THERE'S A HECK OF A LOT GOING ON in the monitor market right now. 4K, curved panels, the promise of HDR—it's all happening. But that doesn't necessarily mean the sweet spot for a high-performance PC monitor, with a bit of gaming in its remit, has changed.

That's where the new AGON AG271QG comes in. It's part of AOC's new high-end line of gaming-centric PC monitors, and it checks an awful lot of our boxes. For starters, it's a 27-inch model, with a 2560x1440 native resolution. That's a very nice compromise between size, detail, desktop space, and GPU load.

In fact, it's probably the best all-round compromise right now, especially if you aren't a fan of multi-GPU gaming. Even Nvidia's latest Pascal graphics cards are marginal when it comes to driving 4K resolutions really smoothly. That's particularly relevant when you consider the AG271QG's next key feature: support for refresh rates up to 165Hz. There's zero chance of playing the latest games at that kind of frame rate at 4K. So that WQHD resolution gives your GPU half a chance of punching out frame rates to do the 165Hz support something approaching justice.

On those occasions when your GPU can't crank out triple-digit frame rates, the AGON also has a solution in the form of support for Nvidia's performance-smoothing G-Sync technology. Factor in a few other additional frills, such as the handy headphone hook on the right-hand side, and the fully adjustable stand, and you have a very nice overall gaming package on paper. AOC even includes a handy mouse-sized programable controller that helps you quick-jump between settings if different presets for various applications are your bag. Nice.

As if all that wasn't enough to get gaming with, we haven't even mentioned the kicker, namely the IPS technology used in the AG271QG's LCD panel. Yup, that's 165Hz refresh and lovely IPS colors, just like the Asus RoG Swift PG279Q, but for about $50 less. Where do we sign up?

DISHING OUT THE DETAIL

Fire the AG271QG up, and initial impressions are good. The IPS panel has a super-smooth anti-glare coating, and thus clean, sparkle-free image quality. The viewing angles are pretty much impeccable, too. In fact, it puts in a very strong performance throughout our test images. Gradients are ultra-smooth, and there's tons of detail in the white scales. Only a whiff of compression in the black scales spoils what would otherwise be a perfect score. Put another way, the out-of-the-box calibration is pretty darn nice.

That 165Hz refresh is just to die for. It's a subtle difference compared to, say, 100Hz or 120Hz. But it's definitely noticeable, and makes for a really responsive screen and solid-looking images. It's so nice, we'll forgive the fact that you have to dig into the OSD to enable a silly overclocking mode to get at the highest 165Hz setting. At least the menu is clear and simple to navigate.

One arguable downside of IPS technology in a gaming screen is pixel response. The AG271QG is rated at 4ms, which is a little off the pace of 1ms TN panels. But for most gamers, most of the time, we doubt they'd notice the very slight increase in blurriness. What they will pick up on is those gorgeous IPS colors and superior contrast. If you're looking for downsides, well, the AG271QG can't compete with its Asus nemesis when it comes to perceived quality. The chassis feels relatively cheap, and the adjustable metal stand is a bit of a lash-up compared to Asus's slickly productized efforts.

But then the AOC is a little cheaper, and such shortcomings have diddly-squat to do with image quality, productivity, or gaming fun. So, you pays your money and you takes your choice. But the new AOC AGON AG271QG is certainly a very plausible new competitor in the performance 27-inch segment. **–JEREMY LAIRD**

VERDICT
9

AOC AGON AG271QG

➕ **A NEW HOPE** Gorgeous IPS panel; awesome 165Hz refresh; tons of gaming-friendly features.

➖ **PHANTOM MENACE** It's far from cheap; build quality is a bit variable.

$750, http://us.aoc.com

SPECIFICATIONS

Panel Size	27-inch
Native Resolution	2560x1440
Panel Type	IPS
Max Refresh	165Hz
Pixel Response	4ms
Contrast Ratio	1,000:1
Inputs	HDMI, DP
VESA Mount	100x100
Warranty	Three years

Sennheiser GSP 300 Gaming Headset

Seriously loud, seriously light

THERE ARE A FEW THINGS every hardware enthusiast needs from a headset, and top of the list is comfort. Rarely do we wear a headset for just a few minutes; if you're going in, you're going in. And so we went in. We anti-socially bolted on Sennheiser's sexy-looking middle-ground cans, and steadfastly refused to remove them, testing them for six-to-eight hour stretches, alternating between marathon *Overwatch* sessions, pumping music, and generally blocking out the rest of the office. And on this count, there's rarely been a headset so well designed. The GSP 300's memory-foam ear cups, coated in silky faux-leather, positively caress the skull, combining with the closed-back design—hinged on to ball joints, which place the cups squarely on even the most angular head—to effectively block out external sound. You're not entirely in your own world, of course. Our colleagues, we assume from their wild gesturing, experienced mild second-hand discomfort when we truly blared the thrash metal, but there's no more leakage than most other closed-back headsets we've tried.

They're also light, to the extent that we legitimately thought Sennheiser had accidentally sent us an empty box when they hit the office, though we have absolutely no concerns about their durability. They're also easily adjusted, with a split headband padded with semi-rigid foam, which keeps the plastic away from the scalp, and puts another check in the wearability box. The clever design doesn't stop there; swing the mic to vertical, and it shuts off, shielding the online world from your disgusting eating sounds, and there's a useful analog volume knob on the right ear cup, adjusted so that it doesn't quite hit zero. You can essentially use it as a booster, turning it all the way down, pumping your computer volume up to a reasonable level, and tweaking upward (slightly—a minuscule 19 ohm impedance means the GSP 300 can reach an eardrum-rattling 113dB) if you need to hear a particularly quiet buddy.

LIVE ON STAGE

On the subject of volume, let's talk sound stage, and tastes thereof. Sennheiser has crafted an interesting one; a rich, bass-heavy, bouncy sound, which is incredibly appealing on first listen, and at high volumes. Almost everything, not just the bass, feels marginally boosted, leaving no sound to the imagination, although the GSP 300s seem to miss a little in the vocal frequencies. It's a massive sound, almost overwhelming—the cans can certainly hold their own at workplace-unsafe volumes, and retain impressive clarity when driven less aggressively—but we felt ourselves yearning for something a little flatter. But that's us. If you like your ears full of fat noise at all times, these will please you no end. But what of the ears of others? The two-sided noise-canceling mic is not, by any means, awful; we had no problems being heard in Discord conversations, and the integrated cut-off comes in useful more often than you'd imagine. It's adequate for streaming or recording, but we'd lean toward a dedicated external mic if we were going for a professional finish.

In isolation, this is a quality headset, a notable notch above budget options. But, to be fair, we also spent a day flitting between the GSP 300 and Kingston's similarly-priced HyperX Cloud II, which, until now, had been our favorite affordable headset. And, by a very small margin, it still is. The Cloud has a more appealing audio balance, a braided cable, as opposed to Sennheiser's rubberized number, and an included USB sound module for fine adjustments; the GSP 300 feels slightly better on the head, and that rich bass is just explosive. Whichever way you lean, make no mistake about it, the GSP 300 is a formidable headset, and if you're contained within cans on a daily basis, it's one that has to be worn to be believed. **–ALEX COX**

VERDICT 9

Sennheiser GSP 300 Gaming Headset

+ DECIBELS Loud, so loud; immensely comfortable; on-ear volume control; decent mic.

− DECIB-HELL Slightly limp vocals; mild leakage.

$100, www.sennheiser.com

SPECIFICATIONS

Driver Type	40mm dynamic neodymium
Impedance	19 ohms
Frequency Response	15–26,000Hz
Design Style	Closed back
Microphone Type	Noise-canceling
Connectivity	3.5mm/4-pole
Weight	12.8oz
Cord Length	8.2 feet

NZXT S340 Elite

Case of the year

IT'S HARD TO SUM UP just how impressed we are with this $100 lump of perfection. NZXT has always made an impression with its cases—since the launch of its H440 back in 2014, the company has been on a winning streak. Whether it's the bold design of the ITX Manta, or the simple and elegant S340, it seems this chassis manufacturer can do no wrong. So when the Elite—an updated variant of the S340—launched, featuring the now popular tempered glass side panel, we had to subject it to our scrutiny.

So, what's so special about this chunk of design? A combination of three things. First, the price. Second, the graciously professional aesthetic. And thirdly, the intuitive design elements when it comes to user convenience. For $100, you get a small, compact tower. Clean and sharp. Almost professional—enough to rival any Mac. The single tempered glass side panel lacks any smoky tint or garish discrepancies, elegantly showing off the innards of your system.

NO EXPENSE SPARED

Delving behind the reconstituted molten sand and into the interior, we're amazed by the quality of the paint job. The satin powdered finish coats the insides of the folded steel panels. Nothing catches, everything is smooth, yet still decisively metallic. The black cable-hide bar elegantly snakes up the right-hand side of the interior, easily hiding any ugly cables you might have from view. There are no rubber grommets to be found here—but, honestly, you simply don't need them.

A look behind the motherboard tray reveals a suitably expansive CPU cutout, and a total of four cable grips dotted around—plenty to route any unwanted cables through—with additional cable tie points positioned nearby. Heading down to the compartmentalized power supply cover, you'll find a mounting cage for two 3.5-inch drives, followed by ample room for your ATX power supply, with plenty of dust-filtered ventilation included. The power supply installs through the rear of the chassis, via a neat screw-mounted bracket, and that's about all there is to it. And then there's the front I/O, which features power, reset, four USB headers, a headphone and microphone jack, and an HDMI passthrough for those VR junkies out there.

Cooling support is a mixed bag. There's room for a 240 or 280mm AIO in the front of the chassis, one 140mm or 120mm fan in the roof, and one 120mm fan in the rear. As there's no 5.25-inch bay in the front of the case, the front panel remains solid. However, there's a good inch and a half of separation between the panel and the fan mounting points, ensuring you can retain excellent airflow while keeping that streamlined style. All in all, the cooling options are pretty limited, but for most people, three or four intake fans in a chassis like this should be plenty.

So, what are the negatives? Well, those of you with OCD may feel a little frustrated by those 2.5-inch SSD mounts situated on top of the PSU cover, screaming for identical drives to be placed in them. When removing those 2.5-inch trays, it could look a little nicer underneath. And we'd happily see a chassis that's a little taller, so you would have a way of mounting a larger radiator or more fans in the roof. But there's little criticism beyond that.

As far as cases go, though, it's the price that's the most impressive feature. In fact, for $100, we're almost convinced NZXT is making a loss on each chassis sold. It's an ATX dream case, with a soft satin touch finish, filled to the brim with little features designed to make the building experience a pleasure for any enthusiast, while continuing to challenge what is the norm in case design. We salute you, NZXT—keep up the good work. **–ZAK STOREY**

VERDICT
9
KICK ASS!

NZXT S340 Elite

+ SOURCE CODE Fantastic finish; super-sleek design; astounding price; easy to build in; adequate cooling solutions.

− SAUCE Still needs more cooling; 2.5-inch display mounts could be better.

$100, www.nzxt.com

SPECIFICATIONS

Form Factor	Midi tower
Motherboard Support	ATX, microATX, Mini-ITX
Colors Available	Black, white, black/red
Window Available	Yes
3.5-inch Support	2
2.5-inch Support	3
Radiator Support	280mm front, 120mm rear
Fan Support	2x 140mm front, 1x 140mm roof, 1x 120mm rear
Dimensions	8.0 x 18.7 x 17.0 inches
Graphics Card Clearance	13.1 inches
CPU Tower Clearance	6.3 inches
Weight	18lb

Cooler Master MasterKeys Pro L White

It looks the part, and will shine on any desk

OH, GOOD: With the MasterKeys Pro, Cooler Master has designed a keyboard for the "brightest possible" backlighting. As marketing points go, it's up there with the bassiest subwoofers, which means there's definitely a market for it.

Outside of the lights—which, on the model we tested, are certainly bright, and a restrained plain white, rather than sporting millions of colors (although these are available, too)—there are some further pleasing touches. The USB cable is a removable micro-USB one, handy if you suddenly need to charge your phone but don't need to type; while instead of plastering the thing with logos, Cooler Master has chosen to rebrand the Windows key as the Cooler Master key. Nice.

The Pro L gives the impression of having a lot of keys but not much board. The only blank spaces are above the arrow keys and to the right of Escape. Every other space is stuffed with keys, each of which has a Cherry MX Brown switch (on our model; Blues and Reds can also be fitted) beneath it. The Blue, with its loud click, still reigns as the office favorite, but the Browns are a good switch, stiffer than the "faster" Red, which feels too light under our heavy fingers. Cooler Master hasn't cheaped-out with inferior switches beneath seldom-used keys, which is always good to see, especially considering the programmability this keyboard offers.

Above the numeric keypad (a tenkeyless "S" version of the keyboard is available), there are four P keys, while at the right of the space bar, you'll find a Fn key very much like that found on laptops. Using this as a modifier, the F keys control every aspect of the keyboard, without needing to go into the bundled software, enabling you to alter the lighting and repeat rate, and record macros, along with switching profiles using the P keys. Holding down Fn gives a readout of the keyboard's current settings, too, reducing the need to remember how you've set it up. It's a thoughtful addition, and one that hugely speeds up any tweaks you want to make to the board, even in the middle of a game. It does mean that you're better off sticking to simple runs of key-presses, however, as the bundled software only programs the lighting, and it's easy to get lost when doing it on the board.

ARMED FORCES

Inside the Pro L sits an ARM Cortex M3 processor, ticking along at 72MHz. This is roughly equivalent to the P54C revision of the Intel Pentium, which had 3.3 million transistors, and was the first chip in the series designed to run at a reduced voltage of 3.3V. The Cortex M3 is a 32-bit chip, also seen as the M9 motion co-processor in the iPhone 6S. It's not hugely powerful, but it's enough to make the Pro L feel snappy in use, with no lag when programming.

Those large, bright LEDs come as a result of a redesigned PCB that has larger holes for them to poke through. It's a shame, then, that the letter cutouts on top of the keys aren't a bit bigger, because this would really show off the engineering. As it is, they're certainly not tiny, and no one's going to complain about not being able to distinguish the letters, but the Fn modifiers, placed down low on the F keys in tiny type, may elude a casual glance if playing in subdued lighting.

The Pro L is well built, and looks the business with its mat-black exterior pierced by the brilliant white of its lighting, but its main problem is the competition. It's priced in a bracket that puts it up against keyboards from the likes of Logitech and Razer, all of which have the same switches (Razer often uses its own rather than Cherry), coupled with better software, and the Cooler Master is likely to be overlooked. **–IAN EVENDEN**

VERDICT 8

Cooler Master MasterKeys Pro L White

➕ **MASTER** Good keys; bright lights; plenty of customization.

➖ **BLASTER** Up against stiff competition; software could be better.

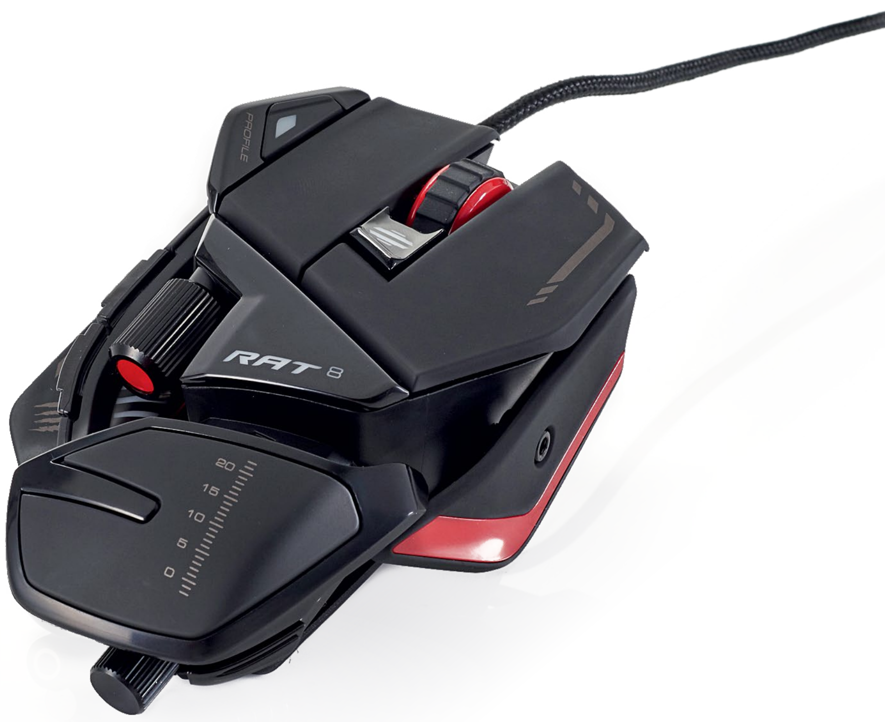
$110, www.coolermaster.com

SPECIFICATIONS

Switch Type	Cherry MX Brown
Form Factor	Full
Media Keys	Integrated
Macro Keys	5
LEDs	White
N Key Rollover	100% anti-ghosting
Passthrough	None
Dimensions	17.3 x 5.1 x 1.7 inches
Warranty	Two years

Mad Catz RAT 8

Mouse with holes takes customization to another level



MAD CATZ HAS BEEN BAFFLING us with its RAT mice since 2010, and now has a full series of the things, from the plastic-bodied RAT 1 to the magnesium RAT X Pro.

The RAT 8 sits near the top of the range, with an aluminum frame hiding under the RAT's strange, deconstructed body. It looks like some sort of advanced running shoe, maybe, or a kind of functional space ship, constructed in orbit, and never intended to fly in an atmosphere. That particularly goes for the black finish with red accents that our review model sports without its lights on.

Oh yes, you get lighting. Mad Catz, hilariously, calls it Kameleon RGB, but the RAT will neither blend into your desktop nor express its emotional state through its hue. This is a standard 16.8 million color system that's set up using the RAT's PC software. It can be set to cycle through every color, to pulse, beat like a heart, or, least distractingly, stay one color, and can be set independently. The patches that light up are small: just the logo on the back, three glowing stripes within the body, and the DPI setting button—areas that are often covered by your palm when in use.

The RAT 8 can be customized to fit just about any hand or gripping technique; a hex key that lives up the tailpipe is used to adjust the position of the thumbrests (although two of the bolts on our sample were extremely hard to move), while the palmrest and side grips can be replaced completely by alternatives included in the box. The palmrest sits above a spring-loaded switch that can be used to shift it back and forward, increasing or decreasing the length of the RAT to fit your hand. This makes it hard to tell whether the RAT is comfortable to use or not—any immediate problems can be smoothed out with a bit of twiddling, while long-term comfort issues may be as much user error as they are design flaws.

The hex key's shaft is buried in a series of metal washers, which can be removed to lighten the mouse (down to 5.1oz), or left in place to make it 5.7oz. That's not a huge difference, but it is noticeable when you lift the RAT off the surface. Don't expect much in the way of weight balancing, as seen on Logitech models, though—the RAT's weights are pressed in place with a spring that keeps them near the center of the body.

MIGHTY MOUSE

Being able to change the weight of your mouse is usually said to be all about speed, and the RAT 8 has all the big numbers for those concerned by how fast their pointer or reticule can cover a screen. The Pixart PMW3360 optical sensor can be cranked up to a sensitivity of 12,000 dpi, with a tracking speed of up to 6.3m/s. The main buttons sit on Omron switches rated for 50 million clicks, and any of the RAT's buttons can be reassigned using the Flux software, with space on the mouse to save three profiles.

That aluminum frame, though it should be stronger than the magnesium in the Pro X, adds weight, but then you don't buy a RAT expecting something super-light. Put one of these in your cart, and you're expecting customizability and strong build quality, both of which the RAT 8 delivers. That said, it may be questionable just how useful those adjustments are—once you've got it molded to your hand, you'll likely never touch them again, and we've found that even the most unusually shaped mice can be got used to with enough time. The RAT's other strength lies in its remarkable looks. Its futuristic, industrial shell, with holes to see into its inner workings, make it a unique object on anyone's desk, and it's this that will attract many buyers to Mad Catz's latest insanity. –IAN EVENDEN

VERDICT **8**

Mad Catz RAT 8

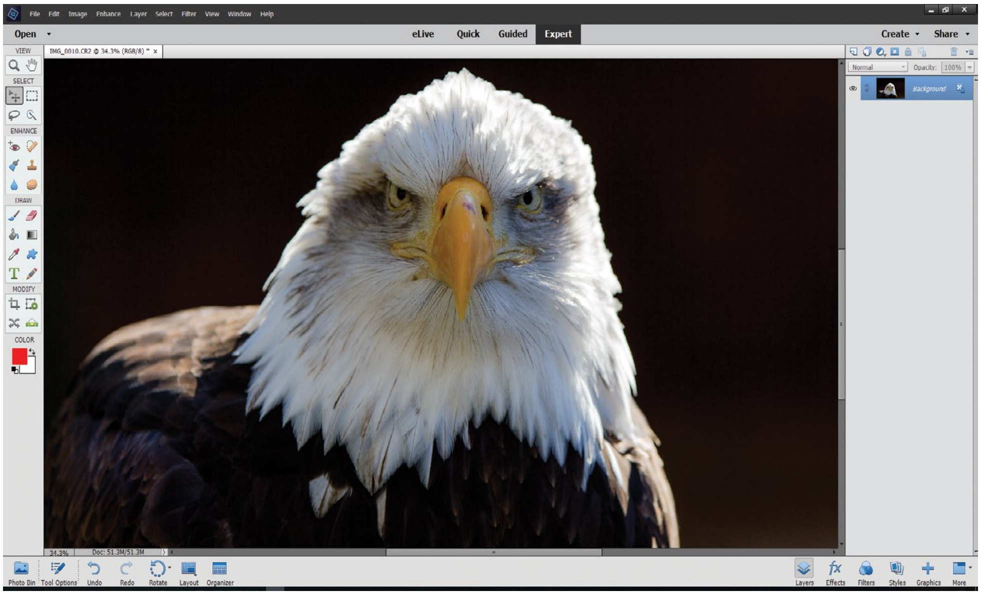
➕ **RATTY** Highly customizable; well built; great features.

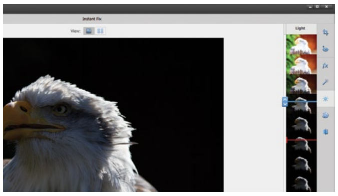
➖ **TATTY** Complex; fixed weight distribution; may be heavy for some.

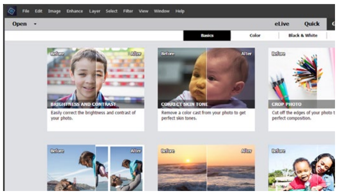
$100, www.madcatz.com

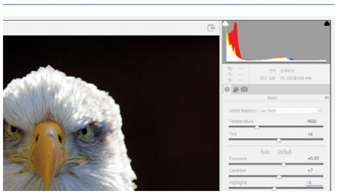
SPECIFICATIONS

Sensor	Optical
Sensitivity	12,000 dpi
Sensor Model	Pixart PMW3360
Polling Rate	125, 250, 500, 1,000Hz
Programmable Buttons	11
LEDs	3 zone 16.8 million colors
Cable Length	6 feet
Weight	5oz









Photoshop Elements 15

Every editing essential in a pared-down pro package

ADOBE HAS VERY MUCH SETTLED on a look for Photoshop Elements, its stripped-down image-editing program. From version 11, each new release of the app has looked virtually the same, with perhaps a different color in the interface, and the changes and upgrades have focused on features.

The application is still split into three "skill levels," with Quick, Guided, and Expert workspaces giving progressively less help and more creative control. New in version 15 are some additional Guided Edits: the ability to add motion blur to images, collage creation, the adjustment of facial features, and the creation of cutout words from images. The big changes are in the Organizer, which gets a bit more love.

Photoshop Elements comes in two halves: the Editor, which is where the editing work is carried out, and the Organizer. The latter scans your hard drive for pictures and analyzes them. If, like us, you've got almost 33,000 image files on your hard drive, this can take some time, even with a quad-core i7—in fact, the whole application is CPU-intensive, because it lacks Creative Cloud's ability to take advantage of your GPU and its fearsome processing abilities. Once it has finished analyzing, you can sort your collection of photos into albums, tag them to make finding them easier in the future, and tell the software to watch folders such as My Pictures, so any future images are added to Elements. Once it's processed your image library, you can search it using automatically generated tags, or those you've added yourself, locations pulled from GPS data, or faces it's detected. Once you start to amass a collection of image files, it makes life a lot easier.

Selecting a picture in the Organizer—which is now touch-enabled, for those with touchscreen laptops—enables you to run an Instant Fix, or open it in the Editor (or another editing app, if you've told Elements where to find it). Instant Fixes can now batch-process images, to cut down on the time you spend editing if you're only making a few tweaks, but you're going to want to use the Editor for anything other than the absolute basics. One of the best things about the Editor is that, if you carry out an operation in Guided Mode, a quick flip into Expert shows you all the edits laid out as Layers and Masks, just as they would be in full Photoshop. It's a great way to learn about the software, and image editing in general.

Opening a Raw file brings you into a version of Adobe Camera Raw that's missing a few of the advanced options you'd find in Photoshop CC—but with the ability to adjust white balance, exposure, highlights, and shadows, plus clarity and saturation, there's enough to work with. Sharpening, noise reduction, and camera calibration are tucked away in the tabbed interface, too, and it's a shame to see these hidden, because they're at the heart of why people choose to shoot Raw files instead of straightforward JPEGs.

One thing about Elements is that its interface can take up rather a lot of your screen; space that could be better used for viewing your image. A few clicks is all it takes to collapse the Photo Bin or Tool Options panels, but it would be nice to be able to change the left-hand toolbar to a single strip of icons, and dock the useful set of floating palettes opened with the "More" button to the right.

If you're looking for a new photo-editing app, Elements 15 is definitely the one to get. It's a well-designed and mature product, free from bugs and unintended features. Owners of version 14, though, need to question whether the few additions to the Organizer and the Guided Edits are worth the outlay. –**IAN EVENDEN**

VERDICT 9

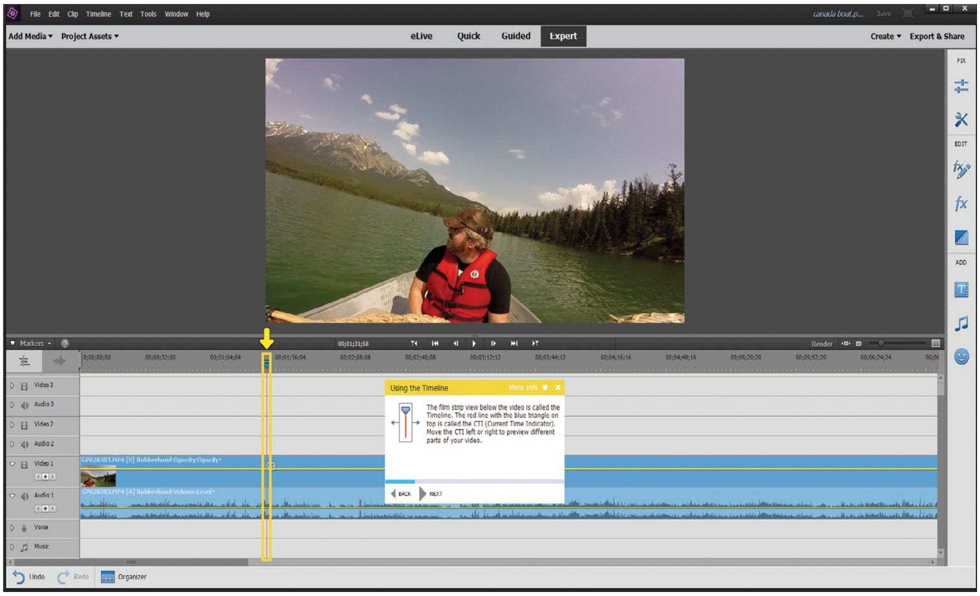
Photoshop Elements 15

➕ **PHOTOGRAPH** Full-fledged image-editing app that does everything a photographer needs.

➖ **POLYGRAPH** Doesn't quite cut it for pro use; GPU acceleration would be nice.

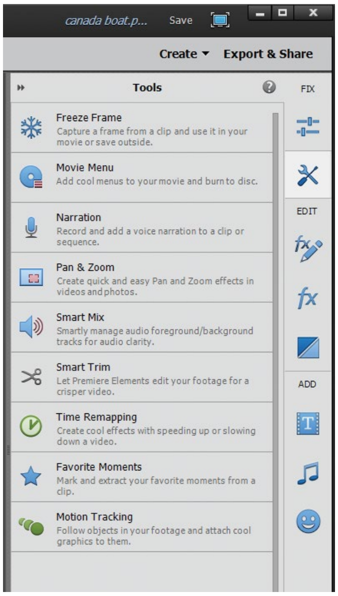
RECOMMENDED SPECS 1.6GHz or faster processor with SSE2 support, 4GB RAM, 5GB free hard drive space, 1024x768 display resolution, Internet connection.

$80 ($150 in bundle), www.adobe.com



Using the Timeline

The film strip view below the video is called the Timeline. The red line with the blue triangle on top is called the CTI (Current Time Indicator). Move the CTI left or right to preview different parts of your video.



Freeze Frame
Capture a frame from a clip and use it in your movie or save outside.

Movie Menu
Add cool menus to your movie and burn to disc.

Narration
Record and add a voice narration to a clip or sequence.

Pan & Zoom
Create quick and easy Pan and Zoom effects in videos and photos.

Smart Mix
Smartly manage audio foreground/background tracks for audio clarity.

Smart Trim
Let Premiere Elements edit your footage for a crisper video.

Time Remapping
Create cool effects with speeding up or slowing down a video.

Favorite Moments
Mark and extract your favorite moments from a clip.

Motion Tracking
Follow objects in your footage and attach cool graphics to them.

Premiere Elements 15

Video editing made as simple as you want it to be

GETTING TO VERSION 15 of an app means it must be doing something right, and with Premiere Elements, that's taking the hopelessly complex art of video editing, and making it appear simple. At least, making something you wouldn't mind sharing on YouTube or Facebook look simple.

It's not, of course. Available as a bundle with Photoshop Elements, or as a standalone app, Premiere Elements makes use of the same Organizer as its photo-editing brother, a clever move that enables you to import both types of media together, and keeps it all in one place. This means it can analyze and tag your videos as it would photographs, detecting faces, and taking even longer about it than with still images. It's unfair to complain about the slowness of this process, however—it's doing a hell of a job.

Video editing is so different from photo editing that it almost feels wrong to sell the two products together, as though they're somehow different sides of the same coin. The raw materials might come from the same camera, but that's where the similarities end.

Adobe's approach to video editing sees you assemble a timeline from your footage, before trimming out the bits you don't want—it's more like sculpture than painting, but you have to make the marble before freeing the artwork from inside it.

Premiere's face detection aims to make this easier, by trimming clips back to the bits that feature people. The idea seems to be that we upload videos to social media with our friends in them, rather than clips featuring mountains or lakes, so this will be a huge timesaver. The emphasis on creating movies to be shared online is underlined by the simple Facebook and YouTube export options. (Smart Trim can be turned off if you're in the habit of shooting pastoral scenes.) Premiere Elements retains the three-mode structure of Photoshop Elements, showing a friendly face to photographers who might be familiar with still image editing, but a little cautious about chopping up video.

HAZY DAYS

More features from Photoshop Elements have migrated over, including the dehazing that originated in Creative Cloud. Applied as an Effects slider from the Advanced Adjustments tab, Haze Removal cuts through partly cloudy skies and foggy backgrounds to reveal the structures and colors buried in them. It does nothing of the sort, of course, being a contrast tweak applied largely to the highlights, but it can reveal a blue sky through wispy cloud, and increase the general clarity and color of the footage. As with the Clarity slider in Lightroom, however, it's possible to overuse it, and end up with a harsh, high-contrast result.

As with many of Premiere's effects, applying haze removal is a two-step process. Firstly, you drop the effect on to the timeline, dragging it out to cover the part of the video you want it to work on. Then it can be set to automatic, or adjusted manually. Another new piece of clever programing that simplifies and shortens the editing process is Remix, which modifies a music track you're using to accompany your video, so it comes to a natural end when the movie does, rather than cutting out suddenly. Elsewhere, you can also now make a collage of video clips, all playing at once in different areas of the screen.

As with Photoshop Elements, Premiere Elements' new features seem focused on special effects, but they're streamlining the video-editing process, rather than complicating it. Converting a mass of raw footage into a coherent narrative is a skilled job, and anything that can take some of the strain is welcome. **–IAN EVENDEN**

VERDICT

8

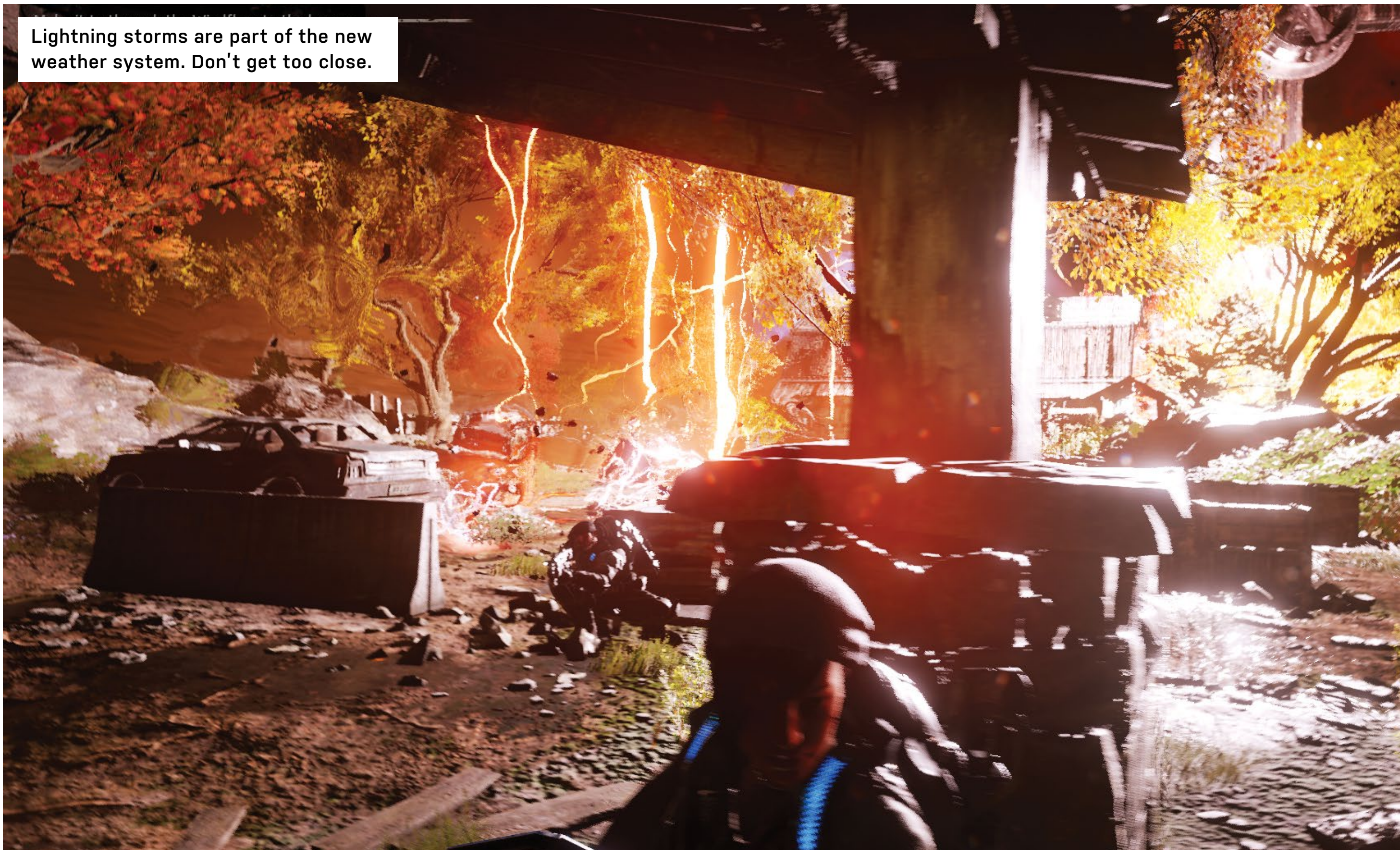
Premiere Elements 15

➕ **KUBRICK** Powerful tools; makes you feel like an expert.

➖ **BOLL** Applying effects can be slow; reading the tutorials is a must.

RECOMMENDED SPECS 1.6GHz or faster processor with SSE2 support, 4GB RAM, 5GB free hard drive space, 1024x768 display resolution, Internet connection.

$80 ($150 in bundle), www.adobe.com



Lightning storms are part of the new weather system. Don't get too close.

Gears of War 4

Cry "Havoc!" and let slip the cogs of war

"I KNEW YOU'D BE BACK, probably with your ass on fire." Growled in a voice that could both dig up roads and re-lay them, it's a line that's appropriate for both the character it's aimed at, and the *Gears* franchise itself.

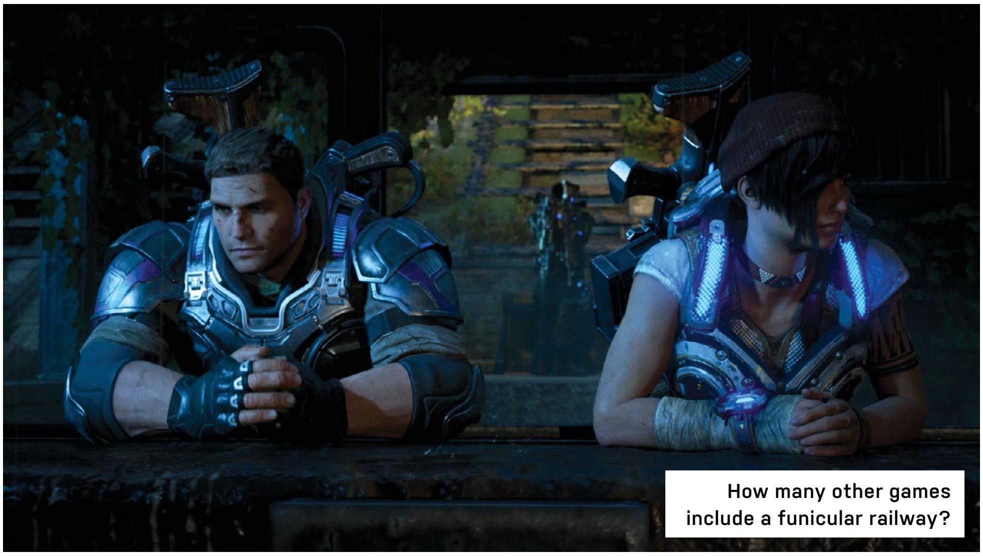
This isn't a series that has traditionally made its home on the PC, with *Gears of War 4* confusingly the fifth game in the lineup, but only the second title to be released outside of the Xbox 360. There is a *Gears of War Ultimate Edition* available on the Windows Store, though, if you'd like to catch up with the plot.

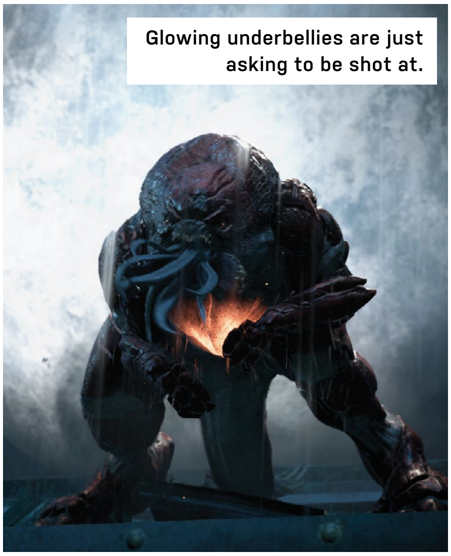
It doesn't matter if you don't. This is a story about sacks of meat with chainsaw-guns going into battle against monsters from underground, who've brought giant crab-spiders with them. We're not talking Steinbeck here. It's a slow-moving third-person cover-shooter, that asks you to lean out of safety for long periods to use its most powerful weapons, while the urge to get up close and use the chainsaw means it frequently devolves into shotgun duels that wouldn't be out of place in the files of *Police Squad.* So far, so Xbox. But the *Gears* series has frequently been used as a showcase for the abilities of the Unreal Engine, all the way back to an Unreal Engine 3 trailer, before we'd even heard of *Gears of War,* that used cog-shaped statues and the kinds of ruined buildings we're now used to in the game. Back at the release of the first game, the developers even released an artbook, *Destroyed Beauty,* to show off their wrecked walls and pulverized plazas.

There's more of the same on offer here—*Gears 4* is an extremely handsome game, with full 4K support, if you've got the PC to handle it. The night sky, in particular, with its looming moons, deserves a pause to appreciate. Extreme weather effects are new to the game, making life difficult for both sides in what's either a heavy-handed metaphor for the dangers of climate change, or a genuine attempt to do something new. It's quite a neat mechanic, affecting enemies and the environment as much as it does our glorious troops, and is tied into the cover system, so you hide from the worst of it, and vault over low obstacles to make faster progress. Weapons receive plenty of ammo; a good thing, considering the lack of accuracy from the most common one, but shots for the special weapons—sniper rifles, grenade launchers, *Unreal Tournament's* sawblade gun—are rationed, and only refilled from dropped enemy guns.

Those enemies can, of course, take a large number of bullets to the head before dropping, both sides having sent their linebackers into battle, with the robotic bad guys who form the opposition during the earlier portion of the game being particularly dull and uninspiring to fight. They're not a great introduction to the *Gears* series for anyone playing it for the first time on PC, and are constantly replenished by airdrop, but go down fairly easily in a hail of bullets. A prolog of flashback scenes means you get to fight some big beasties and handle enormous weapons early on, before it settles down to the metallic grind.

Things change, however, when the Swarm turn up, the original games' Locust reimagined by *Alien Resurrection's* creature designer on a day when he had a particularly runny nose. Their origin,


How many other games include a funicular railway?


Glowing underbellies are just asking to be shot at.

Enough bullets in the engine bring down even the biggest airplane.

The blood spatter is thick, and gets on the camera if you're close enough.

along with a squelchy kidnapping, form the main thrust of the game's plot. Levels are almost completely linear, with only an ammo crate or occasional collectible as a reward for exploring. Your push through the catacombs and caves echoes the first game in the series, something we suspect is completely deliberate.

FORCE PLAY

Just as *The Force Awakens* was a letter to fans from JJ Abrams that said "I got this," so *Gears of War 4,* in the hands of new developer The Coalition, is making the same statement. It's not trying anything new, short of a gentle shakeup of enemy types, and explicitly refers back to them during a trek through a museum in an eerily empty ruined tourist attraction. A motorbike sequence might as well be on rails, and reminded us of Japanese arcade games, as a giant airplane, with turrets that needed to be shot off, swung across our view.

What it is, with its clean-cut young new heroes, is almost sensible. *GOW2* featured a giant worm that undermined entire cities until you chainsawed your way through its guts. Here, robots and Swarm have many of the same units with a skin-swap, and you've almost certainly fought similar types before. They come in waves, the Swarm's equivalent of the airdrop being a hole in the ground that can be sealed with a grenade, and use cover intelligently (most of the time—suicide charges toward your lines, which make more sense when it's a robot about to explode doing it, mean long battles of attrition rarely take place), and attempt to shred you with turret guns, flanking maneuvers, and ravenous creatures that jump on tables while firing quills from their tails.

The entire campaign can be played with a friend in co-op, and a team of AI troops makes a decent job of helping you out when you're solo. A buddy was always along to revive us, even if it meant running straight into a Swarm drone's melee attack. There's further co-op slaughter in Horde mode, which takes the enemy waves of the campaign, and tasks you with defending against them, but we're sad to see that Beast mode (the same thing, but with you playing as the bad guys) hasn't made it over from the previous games in the series.

So here's *Gears of War,* returning to our beloved PC with its ass on fire, looking to make a name for itself in Windows 10 with its good looks, grimly serious shooting, and guns with chainsaws on them. The campaign is a thrill, co-op giving it plenty of replay value, but the whole game is shot through with a sense that the developers are holding back. –**IAN EVENDEN**

VERDICT **8** **Gears of War 4**

➕ **CHAINSAW** Top-class graphics; solid third-person blasting; plenty of monsters.

➖ **RUNNING SORE** Feels restrained; very linear; 73GB download .

RECOMMENDED SPECS Core i5-4690 3.5GHz or FX-8350; GeForce GTX 970 4GB or Radeon RX 480 4GB; 8GB RAM.

$60, http://gearsofwar.com, ESRB: M

LAB NOTES

TUAN NGUYEN, EDITOR-IN-CHIEF

Short Circuits

Burned but fully working

GTX 1080
GEFORCE GTX

I WAS IN THE PROCESS of upgrading the motherboard on my PC this week. I got in two brand new GTX 1080 cards to play with, and figured, hey, why not just upgrade the entire system? So I did that, and pushed the power button. Silence.

The system turned on but nothing actually came on. The motherboard had lights, but no fans were spinning. Nothing. I turned it off, and back on again. Still nothing. After checking to make sure everything was seated properly, I tried again. Nothing yet again. So I figured, let's push the BIOS reset button. Pop! Pop! Smoke. I freaked out.

I immediately unplugged and took everything apart. I saw smoke around the top of the first GTX 1080 and the CPU area, and thought, "Oh no, my brand new GTX 1080!" I sniffed all the components, and there was a bad electrical burn smell on the back of the graphics card that was sitting in PCIe slot 1. I decided to put the system back together piece by piece, and power it on without the GPUs. It booted and POSTed. I was relieved, but then was really worried about the GPU. I put in the second GPU, turned on the system, and it POSTed. Then I thought, "OK, let's try the one that smelled bad." I put both GPUs in, and turned on the system. It POSTed and booted into Windows just fine. Bizarre!

Everything seemed to be working normally. And then I got a CPU temperature warning: 89 C. Uh, oh! I checked the CPU fan and liquid cooler pump. They weren't working. As it turned out, using both CPU_FAN and CPU_OPT is bad, because both headers run on the same power line. So, I moved the connections to other fan headers, and everything worked just fine. And the system has been completely stable ever since.

Don't use the CPU_FAN and CPU_OPT fan headers at the same time!

ALAN DEXTER

Executive Editor

I'm a big fan of technology that makes life easier. Making the complex simpler, more convenient, or cheaper. The problem is, the promise of the new doesn't always pay off in reality. The humble printer has a tendency to fail to live up to expectations more than most. Over the years, I've owned numerous types and models, and rarely have I been truly happy with the results they produce, or the cost they demand to run properly.

None of this stopped me getting my hopes up when I bought my last printer, an HP Photosmart 5520 e-All-in-One. To start with, I thought it was great—the HP software may have been a bit bloated, but the results were impressive for such a mainstream printer, and running costs weren't too awful.

A few years on, though, and this totem of technological frustration taunts the family with its supposed ease of use. What was once a dream of wireless connectivity, is now a nightmare of defiance. More often than not, it sits there, blinking its blue networking light, refusing to acknowledge the wireless router that it used to connect to so eagerly. Arguments are had. Fingers are pointed. And things turn south from there.

What's the solution? It's time to buy a new printer, of course. I'm sure the next one will be much better. It will definitely have an Ethernet port, though.

Editors' Picks:
Digital Discoveries

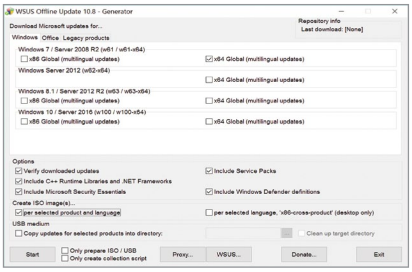
Jarred Walton, senior editor, and Zak Storey, reviews editor, reveal their latest tech loves

WSUS OFFLINE

Not everyone has unlimited data on their broadband, and if you have to update multiple PCs, each one normally has to download all the files from Microsoft's servers. WSUS Offline helps, enabling you to quickly and easily download all the available patches for Windows 7/8.1/10 and Windows Server 2008/2012/2016. It also supports Office 2010/2013/2016, and legacy products, such as Windows Vista and Office 2007.

It uses the Windows catalog file, so works in conjunction with regular Windows Update. It downloads patches from Microsoft's Update servers, and is free under the GNU GPL license. Select all the updates you want, click a button, and WSUS creates an ISO file, or copies everything to a USB stick. It can save time and bandwidth, but there's another reason it's really useful right now.

If you've done a clean install of Win 7 lately, Windows Update gets stuck, and never downloads anything. It's almost like MS is trying to drive a nail into the coffin of Windows 7. If you have a system where Windows 10 doesn't work, relying solely on Microsoft is a dead end. WSUS gets the PC past the initial stall in Win 7, after which you can return to normal Windows Update use. Free, www.wsusoffline.net



Repository info
Last download: [None]

Download Microsoft updates for...

Windows 7 / Server 2008 R2 (w61 / w61-x64)
☐ x86 Global (multilingual updates)
☑ x64 Global (multilingual updates)

Windows Server 2012 (w62-x64)
☐ x64 Global (multilingual updates)

Windows 8.1 / Server 2012 R2 (w63 / w63-x64)
☐ x86 Global (multilingual updates)
☐ x64 Global (multilingual updates)

Windows 10 / Server 2016 (w100 / w100-x64)
☐ x86 Global (multilingual updates)
☐ x64 Global (multilingual updates)

Options
☑ Verify downloaded updates
☑ Include Service Packs
☑ Include C++ Runtime Libraries and .NET Frameworks
☑ Include Microsoft Security Essentials
☑ Include Windows Defender definitions

Create ISO image(s)...
☑ per selected product and language
☐ per selected language, 'x86-cross-product' (desktop only)

USB medium
☐ Copy updates for selected products into directory:
☐ Clean up target directory

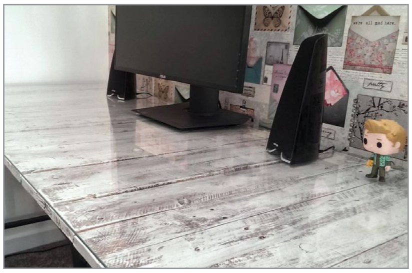
☐ Only prepare ISO / USB
☐ Only create collection script

MY CUSTOM DESK

I knew when I started working at *Maximum PC* and living with my other half, that space was going to be limited. She'd be moaning at me for taking up too much space, and I'd need to carve out as much room as possible, within the limited corner I was given. So I decided to build my own desk. That way, I could define my own dimensions without worry, and choose a style that would match the rest of the decor.

I wanted to do this on the cheap, so I took three pallets from a local wood recycling center, bought two pieces of 2x4, stripped the pallets, sanded down the rough edges, roughed them up a bit with nails, saws, and anything else I had to hand, and nailed them down to the two pieces of 2x4. After that, I applied a dark satin stain, before following up with a rough layer of white paint, and a satin gloss to finish. I laid it out on two trestles from Ikea, with notches chiseled out of the bottom of the two 2x4s for them to sit in, screwed them in, and commissioned a reinforced glass top to provide a level surface, and add that extra bit of glam.

I have very little woodwork experience, and I'm stoked with the results, as it's given me a 70-inch desk to hold all of my PC hardware at home, and for less than $150.



GEEK TESTED & APPROVED

MIONIX PROPUS 380

Mionix Propus 380

YEAH, I KNOW, it's a mousemat. How much time can you spend looking for a mousemat? After all, you can get away with just using the top of a desk if you so desire. But I'm the kinda guy who pursues the finer details. I like a system to be perfect, a desktop to be perfect. And if it's not, it'll frustrate me until it is.

It's not something we test often, and with good reason—the two we have, the Razer Firefly and, more recently, Corsair's Polaris MM800, are gaudy affairs of RGB LED death made manifest. Overpriced, and laden with cables and additional nonsense that just isn't necessary. That said, I am a massive fan of hard mats. Ever since I saw the first aluminum pads in 2013, I wanted one.

Upgrading from my SteelSeries cloth affair, I invested in a Mionix Ensis 320. It was beautiful. My mouse glided across it with ease. However, after a year, it looked as if it'd been involved in a car crash. With the paint stripping away, it was useless. Then I joined *Maximum PC*, and began searching for another. After finding In-Win's BatMat, I thought I was saved. But again, I had problems. This time with grit, and as it grated on the surface, it sent chills down my spine.

The Mionix Propus 380 is the solution, an affordable, flexible hardmat, built from a combination of fiber and hard plastics. It's hard in design, warmer to the touch, and smooth enough for any mouse, yet if grit gets under it, it goes unnoticed. It looks classy, has endured the rigors of eight months of hard use without so much as a single problem, and I'm super-impressed. **–ZS**
$25, www.mionix.net

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON…

> Windows Update
> TV Tuners
> Website Merger

Not an Upgrade

I just got the Windows 10 Anniversary Update, and it feels like things are going backward. I now have a lock screen that I can't get rid of (yet), the computer will no longer sleep, and I've read in your recent issue that my webcam might not work any longer. Things are going backward. I've dug out the old Windows 7 disc, and am waiting for some free time to "upgrade" to Windows 7 from Windows 10. **–Steve G**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We feel your pain, we really do. While Windows 10 works fine on plenty of our machines, there are just enough systems causing problems to make us think that Microsoft's brave new world isn't quite all it's cracked up to be. We've rolled a couple of machines back to Windows 7, and they've been behaving just fine. The only thing we recommend if you are going to do this is to make sure that you have a quality antivirus regime in place—to protect yourself as much as possible with the ageing OS. That's about it, though. Oh, you won't be able to play *Gears of War 4* or *Forza Horizon 3*, but that's a hit lots of us are willing to take.

Turn On, Tune In

I appreciate the change in pace for the "Build It" this month, but where's the TV tuner card? Or the Blu-ray drive, for that matter? I realize your stated goal was a Roku PC, but it could do so much more with just a bit more cash. With the loss of Windows Media Center, we HTPC DVR enthusiasts are left fending for ourselves on Media Portal or Kodi forums (the only two I can think of; never got the latter to work). This month's "Build It" was a tease, which turned out to be a tiny and weak computer. You seem to like covering random niche software how-tos (typically paid) in this section—how about some love for those of us with TV tuner cards? **–James Breen**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: The way we watch television has changed, at least as far as the vast majority is concerned. Scheduled television is quickly being replaced with streaming options—the likes of Netflix, Amazon Prime, and YouTube. Our recent "Build It" reflected this shift, and was designed in part to show just how easy it is to build a machine that can do the vast majority of what you need, without needing to reach for a TV tuner (because, let's face it, TV tuners have always been far more frustrating than they had any right to be).

Having said all that, there is still a place for TV tuners, and this is something we'll look at in a forthcoming issue. As you rightly say, though, given the lack of support from Windows 10, you may have to wrap your head around some form of Linux in order to make the most out of your hardware.

Broken Update

I have been mulling over putting together a last hurrah machine for my AMD 8350 CPU, with updated SSD, and Windows 7. I just finished upgrading my Mini-ITX with an ASRock AM1B motherboard, and an AMD 5370 CPU. My question is about Microsoft Update. After building the Mini-ITX machine, I set Update to "Automatic." Since this is a complete rebuild (the AMD E350N system took a dump), the little computer has refused to update. I went to http://support.microsoft.com/en-us/kb/3125574 hoping to be able to get all updates in one package. I was able finally get to Microsoft Update Catalog, and figure out how to download the Windows 7 update. The unfortunate thing is that it comes with a standalone Updater/Downloader that initially starts to download and update the computer, then starts an endless search for updates on the computer. This same thing happens when I go to MS.com Update, and try using the "Update" button. If I use the computer system "Update" box, it starts an endless search for "gomicrosoft.com." I hooked up an HP LaserJet 6MP to search for a driver, and the computer opens IE, and endlessly waits for "gomicrosoft.com" to update from Microsoft's files. I used the same Win 7 Home software that the E350N system used. It seems to me that MS is blocking Win 7 updates, because I can download some updates to the HD, but they will not go past the "Update→Search for updates" routine.

I'm not a gamer, nor do I work in IT, but I have two 8350 microATX Win 7 systems that have started

↘ submit your questions to: comments@maximumpc.com doing the same thing—that is, they will not update, but go into an endless search for updates. Unless I can resolve this "update" problem, my rebuilding one of my microATX systems into an ATX beast (for an AMD system) is on hold. What's going on, and what can I do? **–Leslie Nelson**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: There have been a few problems with the Windows 7 updater, so spotting which particular conflict is stopping your machine can be tricky. You've got the right idea though—by going directly to a specific Microsoft knowledge base article, you can try to bypass the problematic update, and start the whole process rolling again. My suggestion would be to point your browser (Internet Explorer is your best bet here) at https://support.microsoft.com/en-us/kb/3135445, and hit the link next to the "All supported x64-based versions of Windows 7" entry. Once downloaded, apply the patch, and restart when prompted. After the restart, select "Windows Update" from the Start menu, and you'll be able to install updates as normal. If you have no luck with this method, check out Jarred's suggestion in this month's Lab Notes (pg. 92), as it highlights how to use WSUS Offline.

Big Screens

I saw in the letters section (Dec 2016) that you are planning a write-up of large-screen monitors. That's awesome! I've had a 50-inch Panasonic TH-50PHD8UK plasma monitor for 11 years, and it is fantastic. However, I recently built one of your Turbo Builds (Dec 2016), and would love to add to my 50-inch Panasonic with a 65-inch monitor. I do not need a tuner, such as a TV tuner, since I hook up to a cable router for broadband, and have the audio through my Denon HTPC receiver. I would also like to spend less than the $4,000 that my 50-inch Panasonic cost me if possible. **–Kevin Michael**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: A good quality screen is one of the few pieces of hardware that you can get so much out of—getting 10 years-plus out of a screen is impressive, and we struggle to think of any other component that lasts as long. I'm sure it'll be part of the buying advice, but paying for quality tends to work out in the long run.

The roundup is definitely on the way, but we've pushed it back a couple of months due to the imminent arrival of more HDR screens—they're a game-changer, which is why we've dedicated a feature to the technology this issue (see pg. 48). We'll also be covering projectors in the test, as they can be a great option when looking at really large displays.

Merger Reservations

I have been a subscriber for years. So, when I read that *Maximum PC* had merged with *PCGamer,* I thought "No problem. Gamers understand the need for hot computers, so this is a natural fit."

I now need to rebuild my computer. It's six years old, and getting very quirky (including repeated BSODs of late). So, I went to the website to see your very latest recommendations, and was profoundly disappointed to see how amputated it is. I wanted to see, on the website, the three standard builds (budget, medium, high). I can't find them there.

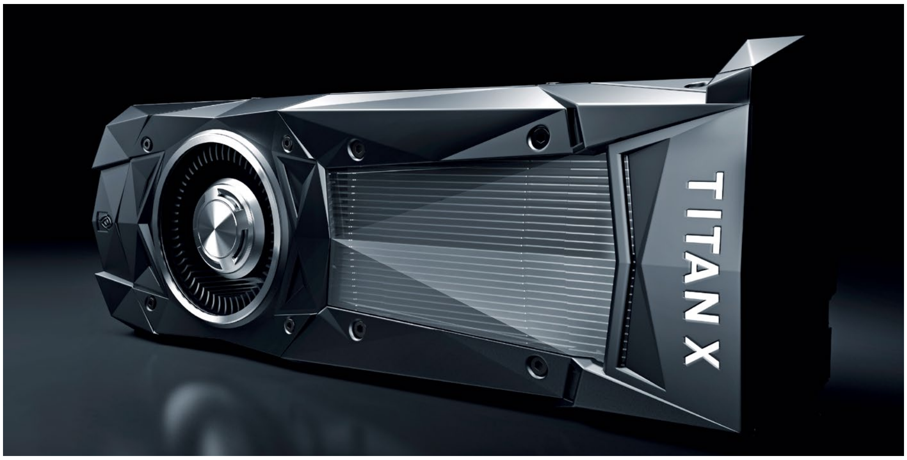
I wanted to see recommendations about components—except for the ones with specific articles, they aren't there. I remember seeing a recommendation for ODD in the magazine. I've not been in the habit of tearing out bits of the magazine so I can find them later. I was sure I'd easily find your ODD recommendation on the website. No, couldn't find it.

I assume there's a fear that if you give away the milk, nobody will buy the cow (the magazine). OK, please, let's have our old level of data, with subscriber passwords for the full text. Pretty please? **–Don Green**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: We haven't had chance to put everything we want to on the new site, but it's coming, and a lot of the information you're looking for is available—especially if you combine it with content in the magazine. For instance, if you want to upgrade, you can use the "Build It" section at the back of the mag, and check the latest recommendations from the buying guides online (www.pcgamer.com/hardware/buying-guides/). As for optical drives, just get the best deal—there's very little separating the best from the worst. They're definitely not as vital as they once were.

[NOW ONLINE]

NVIDIA ISN'T SPYING ON YOU



Nvidia came under fire recently for allegedly gathering personal data from its users via the telemetry monitor in Nvidia GeForce Experience. Some of the more conspiratorial posts on the Internet believe Nvidia is sharing this data with the NSA. However, it appears that the suspicions were largely unfounded, and Nvidia is simply gathering fairly innocuous data on games and hardware. Nvidia's GeForce Experience is software designed to keep your PC updated with the latest drivers, and it also has tools for monitoring your hardware and adjusting game settings accordingly. Read the full story online at http://bit.ly/2fA73x5.

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TAKE IT FROM A GEEK.℠

THE BUILDS

BUDGET

INGREDIENTS

PART		PRICE
Case	Thermaltake Core V1	$49
PSU	EVGA SuperNOVA 550 GS	$83
Mobo	ASRock H170M-ITX	$85
CPU	Intel Core i5-6500	$205
GPU	Zotac GeForce GTX 1060 Mini 3GB	$200
RAM	8GB (2x 4GB) Crucial Ballistix Sport LT DDR4-2400 **NEW**	$47
SSD	256GB SanDisk Z400s 2.5-inch SSD	$70
HDD	1TB Hitachi 7,200rpm 3.5-inch SATA	$46
OS	Ubuntu Desktop Linux 16.04 LTS 64-bit	$16

Approximate Price: $801

THERE'S ONE COMPONENT CHANGE and a slight price increase on the Budget system this month, due to price bumps on the case and hard drive. The only item we swapped out was the RAM: The HyperX Fury kit we used last month saw a hefty price increase, so we grabbed a pair of Crucial Ballistix Sport LTs instead this time around. The new DIMMs operate at the same frequency, but the latencies are a little slower at 16-16-16, as opposed to 14-14-14, so if you can afford more responsive memory, that would be where we would put our money. Quick piece of advice: Keep an eye out for flash sales. When we were checking the prices of this machine, we saw some great one-day deals on MSI and Gigabyte cards. In fact, combine such sales with rebates, and you could pick up the likes of the MSI GeForce GTX 1060 3G OCV1 for as little as $170 after rebate—a sound $30 saving over the Zotac that we have here.

MIDRANGE

INGREDIENTS

PART		PRICE
Case	NZXT Manta	$120
PSU	EVGA SuperNOVA G2 650W 80 Plus Gold	$90
Mobo	ASRock Z170M-ITX/ac **NEW**	$124
CPU	Intel Core i5-6600K	$237
Cooler	Corsair H100i v2	$103
GPU	Gigabyte GeForce GTX 1070 **NEW**	$390
RAM	16GB (2x 8GB) G.Skill NS Series DDR4-2400 **NEW**	$80
SSD	250GB Samsung 850 EVO M.2	$98
HDD	Western Digital Black Series 1TB 7,200rpm	$69
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $1,411

THE GIGABYTE GA-Z170N-GAMING 5 that has formed the backbone of this machine for the last few months saw its price jump up to $160, which we could have absorbed, but in the interests of trying to make our money stretch further, we decided to give the ASRock Z170M-ITX/ac a shot at the big league. This compact motherboard crams a lot into its Mini-ITX form factor, including dual-Gigabit Ethernet, 802.11ac Wi-Fi, and six USB 3.0 ports. Prices continue to move in the mid- to high-end graphics card space, so we've opted for a Gigabyte GeForce GTX 1070—you may well be able to get a better deal the day you're buying, though. Memory pricing continues its march upward, too, which had us opting for a pair of G.Skill NS Series sticks. They lack fancy heatspreaders, but run just fine, and offer decent value for money. With subtle price shifts here and there, we've seen the overall price of this rig drop by $25, which isn't bad for the same raw power.

TURBO

INSPIRED BY OUR UPGRADE FEATURE, and the longevity you can expect from a workstation, we've finally pulled the trigger and decided to upgrade the Turbo build to use one of Intel's latest Broadwell-E Extreme Edition processors. Decision made, the first thing we faced was a 10 percent price hike for our motherboard of choice, the Asus X99-A II. Despite the increase, we still want it, because it boasts a great feature set, with plenty of potential for upgrades and expansion.

When it comes to Broadwell-E, there's one processor that stands out for us: the Core i7-6800K. This six-core chip manages the price/performance balance better than any other Broadwell-E chip, offering 12 threads of computing power, running at 3.4GHz as standard, and it's ripe for overclocking, too. We can't quite justify the leap to the Core i7-6950X, as that has a price tag of $1,650, but if you're building this machine for work, the added power you get from those four extra cores could be worth it.

We've seen memory prices increase across the board, and it's no different here. The Ripjaws we've been using were heading toward $200, so we picked up a Corsair Vengeance LPX kit for our first Broadwell-E outing. Elsewhere, we saw a price increase for Intel's 1.2TB SSD, but we wanted to stick with this for now. Overall, our rig costs nearly $200 more than our previous Turbo build, but you can expect some nicks and tucks as we tweak the setup moving forward.

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Evolv ATX	$160
PSU	EVGA SuperNOVA G2 750W	$111
Mobo	Asus X99A II	$220
CPU	Intel Core i7-6800K **NEW**	$440
Cooler	Corsair H100i v2	$103
GPU	EVGA GeForce GTX 1080 SC Gaming	$645
RAM	32GB (4x 8GB) Corsair Vengeance LPX DDR4-2666 **NEW**	$168
SSD	1.2TB Intel 750 Series PCIe SSD	$800
HDD	4TB WD Black 7,200rpm 3.5-inch SATA	$207
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $2,954

UPGRADE OF THE MONTH

INTEL® CORE™ i7
i7-6800K
SR2PD 3.40GHZ
J604C745 e4
769UD84201280

INTEL CORE I7-6800K

AMD's Zen really could mix things up at the high end, but we can't hold off upgrading to Intel's latest chips any longer. Likewise, if you need the power that such chips offer, then you probably can't afford to sit around twiddling your thumbs either. This may not offer a monumental leap over the previous generation in real terms, but as we've seen from this month's upgrade feature, such chips do stand the test of time incredibly well, so if you can put it to work to earn its living, you should be able to reap the rewards quickly.

$440, www.intel.com

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